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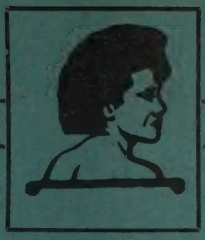

COLONY OF FIJI

AGRICULTURAL JOURNAL

ISSUED BY THE

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Notes for Librarians and Research Institutes

AGRICULTURAL JOURNAL, 1928-55

So many requests are received for parts of the " Agricultural Journal " which were never published or which are now out of print, that the following list of all issues published is given for reference. Those volumes and numbers which are not now available are marked with an asterisk. It will be noted that copies of all parts of ten volumes and parts of nine other volumes are unobtainable. Should any reader have unwanted copies of these publications, the Librarian would be grateful to receive them.

Vol.			Vol.		
1.	3 numbers,	1928.	14.	4 numbers,	1943* (No. 3).
2.	4 ,,	1929.	15.	4 ,,	1944* (No. 2).
3.	3 ,,	1930.*	16.	4 ,,	1945.*
4.	4 ,,	1931.	17.	4 ,,	1946.*
5.	2 ,,	1932.*	18.	4 ,,	1947* (No. 1 and 4).
6.	2 ,,	1933.	19.	4 ,,	1948.*
7.	1 ,,	1934.	20.	4 ,,	1949.
8.	4 ,,	1935-7.*	21	3 ,,	1950* (Nos. 1 and 2).
9.	4 ,,	1938.*	22.	1 ,,	1951.*
10.	4 ,,	1939.*	23.	3 ,,	1952.* (Nos. 3 and 4).
11.	4 ,,	1940.*	24.	4 ,,	1953.* (Nos. 1 and 2).
12.	4 ,,	1941* (Nos. 1 and 2).	25.	4 ,,	1954.* (Nos 1 and 2).
13.	4 ,,	1942* (Nos. 1 and 2).	26.	3 ,,	1955.

AGRICULTURAL CIRCULAR, 1920-25

NUMBERS and year of issue of the " Agricultural Circular " :—

Vol. 1, 1920, 12 numbers. Vol. 4, 1923, 1 number.
2, 1921, 5 ,, 5, 1924-5, 2 numbers.
3, 1922, 4 ,,

As number 4 of Vol. 3 was printed as " Volume 4 " and number 1 of Vol. 4 as " Volume 5 " it would appear from an inspection of a complete set that Volume 4 comprised only a number 4 and that there were two issues of Volume numbered as 5, No. 1.

ANNUAL BULLETINS, 1931-38

COPIES of Annual Bulletins of Divisional Reports for the year 1933 and 1934 ONLY are availabie.

AGRICULTURAL BULLETINS, 1911-55

A FEW copies of the following bulletins are available at the prices shown. Other Bulletins previously listed are out of print.

No. 1. Sisal Hemp in Fiji, by C. H. Knowles, 1911. Price 2s.
7. A Mission to Java for a Coleopterous Pest of Bananas, by Jepson, 1914. Price 2s. 6d.
23. Insect Pests of Fiji, by R. J. A. W. Lever, 1946. Price 1s.
24. The Botanical Gardens, Suva, by J. W. Parham, 1948. Price 1s. 6d.
25. Copra Drying and Copra Driers, by W. J. Blackie, 1950. Price 1s. 6d.
26. Mechanisation of Rice Padi Cultivation by R. R. Mason. Price 2s. 6d.
28. Soil Erosion and its Control in Fiji, by C. E. Whitehead. Price 2s.
29. Annual Reports of Divisional and Specialist Officers 1954. Price 4s.
30. The Grasses of Fiji, by J. W. Parham. Price 5s.

AGRICULTURAL REPORTS

RECENT reports on Agricultural subjects are available as follows :—

Rhinoceros Beetle Eradication Board. Report C.P. No. 39, 1954. Price 1s. 6d.
Coconut Rehabilitation Committee 1954. Report C.P. No. 40, 1954. Price 1s.
Department of Agriculture Annual Report, 1953. C.P. No. 37, 1954. Price 5s. 6d.
Department of Agriculture Annual Report for 1954. C.P. No. 9, 1955. Price 2s.
Report by Sir Geoffrey Clay on his Visit to Fiji in 1954. C.P. No. 31, 1955. Price 1s. 6d.
Department of Agriculture Annual Report for 1955. C.P. No. 8, 1956. Price 2s.

OTHER PUBLICATIONS

A FEW copies of the following important book are available :—

The Coconut Moth in Fiji, by J. D. Tothill, H. C. Taylor and R. W. Paine. Imperial Bureau of Entomology, 1930. Price £1.

FORTHCOMING PUBLICATIONS

THE following publications are in the press and will be available shortly :—

Bulletin No. 31 ... ... The Declared Noxious Weeds of Fiji and their Control, by T. L. Mune and J. W. Parham (approximately 72 pages and 33 illustrations).

Book ... ... The Fishes of Fiji, by H. W. Fowler (approximately 600 pages and 200 illustrations).

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ISSUED BY THE DEPARTMENT OF AGRICULTURE, FIJI

AN APPRECIATION--Mr. B. E. V. PARHAM

Mr. B. E. V. Parham, O.B.E., Deputy Director of Agriculture, left Fiji on the 18th April, 1956, on pre-retirement leave; he has accepted appointment outside the Colonial Agricultural Service as Director of Agriculture, Western Samoa.

Mr. Parham came first to Fiji with his parents in 1920. He received his professional education at Canterbury University College, New Zealand, where he graduated Master of Arts with Honours in Botany in 1930. For two years he was employed in New Zealand ; at Canterbury as Assistant Lecturer and Demonstrator in Botany, as Wood Technologist and Pathologist with the State Forest Service, and later as Fruit Research Assistant in Mycology at the Cawthron Institute, Nelson.

He accepted appointment to Fiji on the 7th March, 1933, as Assistant Agricultural Officer. The principal duties of this appointment were originally the investigation and control of plant diseases with particular reference to bananas, but on account of staff exigencies and the financial stringency of the times he was drawn inevitably into the wider field of general agriculture and was for many years Agricultural Officer in charge of the southern agricultural division, which then included the old Central Agricultural Station (Navuso and Naduruloulou). Throughout his service however, he maintained his strong interest in botany and mycology and despite lack of official recognition he undertook for many years the duties of departmental botanist and mycologist. His personal interest in this work, which was largely undertaken in his own time, laid the foundations of two Colonial Development and Welfare Research Schemes concerned with botanical and plant disease investigations and it must have been gratifying to him to see the establishment before he left Fiji of a well equipped herbarium and botanical laboratory in which his collection is housed. The botanical section is now in the charge of his son, Mr. John Parham, at present Assistant Botanist. A part of Mr. Parham's old station, Naduruloulou, is now the Plant Introduction and Quarantine Station, a regional institution supported by the South Pacific Commission. Mr. Parham took a close personal interest in the development and management of this station and he planted up the arboretum which forms an interesting and valuable section of it. Another project for which he was largely responsible is the Grass-seed Production Farm in Ra Province.

Mr. Parham was promoted Senior Agricultural Officer in July, 1945, and from 1947 to 1949 he acted conjointly as Economic Botanist and also Registrar of Co-operative Societies. He was awarded the O.B.E. on the occasion of His Majesty's Birthday in 1949. In April, 1953, he was promoted Deputy Director of Agriculture and he acted as Director during the greater part of 1954.

During his service Mr. Parham developed and maintained a deep interest in Fijian agriculture and he will be very well remembered by large numbers of Fijians for his patient hearing of their difficulties and for the assistance he gave not only directly to many Fijian farmers, villages and co-operative groups but indirectly through the training of many of the Field Assistants who now serve the Department. His fluency in Fijian and his knowledge of Fijian custom greatly assisted him in this part of his work ; he passed Lower Standard Fijian with Honours in 1934, and followed this the next year by passing the Middle Standard Fijian examination with 70 per cent marks. He thus set an example which is followed only too seldom by extension officers in these days.

In 1949 Mr. Parham was appointed member for Economic Development on the Research Council of the South Pacific Commission and in the same year attended the United Nations Scientific Conference on the Conservation and Utilization of Resources at Lake Success as a representative of the South Pacific Commission. He still remains a member of the Council.

Mr. Parham was a foundation member of the Fiji Society of Science and Industry (now the Fiji Society) when it was first formed in 1938. He has played a very

active part in the work of the society and has been either President or Vice-President during the greater part of the society's life.

He is the author of a large number of articles, principally in the Fiji Agricultural Journal, on subjects connected with economic botany. One of his most popular and useful publications is "Fijian Plant Names" (published 1942) which has helped and interested all those who have wished to know more of Fiji plants. His paper, the Naturalized Flora of Fiji with Special Reference to the Grasses, Legumes and Weeds, read before the 7th Pacific Science Congress of the Pacific Science Association, is a valuable record of the changes that have taken place in the flora of Fiji during the Colony's more recent history.

" B.E.V." will be sadly missed in the department which he has served so long and so well and we wish him and his wife every happiness in their new home. It is some satisfaction to know that he is continuing his work within the South Pacific where his unrivalled knowledge of the botany and agriculture of the region will be of benefit to workers and agriculturalists in all Pacific territories. C.H.

AGRONOMY . . .

A RESPONSE OF RICE TO LAU (OGEADRIKI) PHOSPHATE

BY N. G. CASSIDY

Previous experiments have failed to give a single recorded case of response to Ogeadriki phosphate. It has now been shown that under flooded conditions rice will respond well to Ogeadriki phosphate but the use of superphosphate is even more economic.

A previous article in this Journal (Cassidy 1952) described the general nature of the fine, loamy, natural phosphate which occurs on the island of Ogeadriki in the Lau Group. It was shown that in the chemical composition of this material there is sufficient aluminium present to combine with all the phosphate, and that there is considerable iron present as well. Under these conditions it is unlikely that any of the phosphate is combined with calcium, although calcium is present in amounts chemically equivalent to the sum of the aluminium and the iron. This contention is supported by the fact that only 1% of the total phosphate is soluble in citric acid. It follows from the chemical evidence that Lau phosphate is of such insoluble material as to be of doubtful value as a fertilizer.

It was also pointed out, in the article referred to, that attempts to use Lau phosphate as a fertilizer in a number of pasture top-dressing trials (mostly of an observational nature) had failed to show any beneficial effect, even though superphosphate was apparently successful in many of these cases.

At the same time it seemed likely that, in the special case of the fertilization of paddy rice under truly anaerobic conditions, where the soil surface is kept properly flooded, Lau phosphate might prove successful.

The purpose of the present note is to show that this expectation has been realized in greenhouse experiments in which rice was grown in pots under flooded conditions, using different forms of phosphate fertilizer. A detailed account of this work is to be found in the article immediately following, in this Journal. The results with Lau phosphate only, may be briefly stated as follows :—

> Two soil types were used, Navua clay loam and Tokotoko clay loam, both of which are well adapted to the cultivation of wet rice. Lau phosphate was applied at the heavy rate of one ton to the acre, because of its insolubility.

This was compared with superphosphate applied at 2 cwt. per acre on Navua soil and at 4 cwt. per acre* on Tokotoko soil. The rice variety was New Guinea.

The experiment was continued using the same pots to grow a second crop of rice ; and in the case of Navua soil another set of pots, freshly treated with the phosphate fertilizers, was also included so that first-crop effects could be compared with second-crop (or residual) effects. Finally the two sets of pots representing first and second crops were replanted with rice so that a comparison between second and third crops became possible. In all except the final experiment (third crop) with Navua soil type, total weight of straw was the quantity measured ; but in the final experiment the weight of seed head was taken and the increase in grain was shown to be of the same order, under the conditions, as the weight of straw. It is therefore reasonable to assume that increases in weight of straw would have been accompanied by similar increases in grain.

In order to allow comparisons to be made between the three series of trials, the average yield of the control pots, that is the no

* Actually a dressing of calcium monophosphate was used in the Tokotoko trial.

phosphate-no nitrogen treatments, has been taken as 100 and each of the other yields has been given on this basis. This method overcomes to a considerable extent the effect of different periods of growth, for all experiments did not run for the same length of time.

	Series	No phosphate Without nitrogen	No phosphate With nitrogen	Lau phosphate Without nitrogen	Lau phosphate With nitrogen
FIRST CROPS—					
Navua soil ..	I	100	107	344	220
	II	100	..	322	..
Tokotoko Soil ..	I	100	116	217	303
SECOND CROPS—					
Navua soil ..	II	100	125	133	133
	III	100	..	210	..
Tokotoko soil ..	II	100	94	158	192
THIRD CROP—					
Navua soil ..	III	100	275	425	300

Under the conditions of the experiment there was a consistent response of rice to Lau phosphate, with apparently no improvement if nitrogen as ammonium sulphate was supplied in addition. However, in these trials it was notable that the superphosphate treatment was in all cases about twice as effective as Lau phosphate and since the superphosphate was used at a much lower rate, it must be concluded that the relative value of Lau phosphate is only about 10 per cent—15 per cent that of superphosphate. This finding applies also to the residual value of the fertilizers. (For further detail the reader should refer to the next article in this Journal). With superphosphate valued at about £20 per ton, Lau phosphate would therefore be worth about £2 to £3 per ton.

Although Lau phosphate has therefore been shown to have a real value as a fertilizer in the special case of the growing of rice under flooded conditions, superphosphate would be preferred owing to its lower cost. However, for local use within the Lau group, it might be economic to use Ogea-driki phosphate on padi rice.

It is worth placing on record, that, should a situation arise in which superphosphate is unavailable, Lau phosphate would prove a real asset for the Colony's rice crop.

EXPERIMENTS WITH RICE ON PADI SOILS

I. GREENHOUSE TRIALS

By N. G. CASSIDY

Most of the land used on Viti Levu for the growing of lowland rice belongs to one of the two soil types Navua clay and Tokotoko clay.

Navua clay is an alluvial soil derived from mixed sediments. It occurs extensively in the south-east part of Viti Levu and is to be found where the levee bank of a creek or stream drops away to lower levels; it is therefore rather poorly drained, and shows a profile of about six inches of light brown clay loam on brown to reddish brown or yellowish brown clay loam; reddish brown mottling indicative of restricted drainage appears in this profile, particularly in the second horizon.

Tokotoko clay is closely related to Navua clay and is in fact the soil to be expected when going farther away from the stream, to the lowest bila land. Here the water-table is high at most times of the year, so that the lower horizons of the profile are grey or bluish. The topsoil is usually about six inches deep and is brown in colour; beneath this is grey or bluish clay (possibly in more than one horizon), showing reddish-brown as well as bronzy mottling. The greater number of colours in Tokotoko soil contrasts with the more uniform colour of the Navua profile.

These are the main padi soils of the wet zone. Metahaloysite and gibbsite have been recognized as prominent among the clay minerals of Tokotoko but no information of this kind is available regarding Navua.

The chemical characteristics of these soils indicated that it might be possible to improve on rice yields by the use of phosphatic fertilizers, and a sequence of greenhouse experiments was carried out to test this hypothesis.

Rice of the New Guinea variety was grown in tinned cans 5 inches in diameter and 7 inches deep. These were converted to usable pots by painting them inside with bitumenous paint and outside with a white enamel. No drainage was allowed as it was part of the experimental treatment to grow the rice under flooded conditions. The seeds were hot-water treated for 10 minutes at 52°C, and seven days later were planted in the pots : the shoots were then one to two inches long. One seedling was left to grow in each pot and when the seedlings were about four inches high the pots were flooded and, as far as practicable, an inch of standing water was maintained in all pots at all times.

Treatments were No phosphate, Lau phosphate, Rock phosphate and Superphosphate, with and without ammonium sulphate. The two insoluble phosphates (Lau Ogeadriki) and Rock (Ocean Island) were used at a rate equal to one ton per acre. Superphosphate was used at two cwt. per acre for Navua and four cwt. per acre for Tokotoko,* and ammonium sulphate at three cwt. per acre in each case. There was no rock phosphate treatment in the Tokotoko series : and there were two replications of each treatment in the Navua series and three in the Tokotoko. The insoluble phosphates were placed two inches below the surface and the superphosphate was mixed with the top inch of soil. Ammonium sulphate was applied as a solution. All pots were flooded about 10 days after transplanting.

In order to make comparisons possible between the different series, the yield from the Control plots was given a value of 100 in each case and all other yields in the series were related to this.

The experiments were carried out in three different series. In the first series, on both soil types, the effect of fertilizer applied to the current crop was determined. In the second series the identical pots used in the first series were replanted with rice of the same variety and a second crop was grown. Data were therefore available for comparing the residual effects of the fertilizers with their immediate effects as determined in Series I. In addition a new set of pots containing fresh Navua soil was prepared as in Series I (but omitting the nitrogen treatments) so that it was possible simultaneously, i.e. during the same growing period and under identical growing conditions, to compare the effect of the fertilizers on the current crop with the effect of the same fertilizers applied to the previous crop. For Tokotoko soil, a second crop *only* was grown in Series II.

In Series III the two sets of Navua pots were again replanted to rice : this allowed a comparison of second crop with third crop effects. About half of the straw harvested from each pot was returned to the surface of the soil in a finely-ground form.

Series	Growth period
I	June-August, 1954 .. ..
	July-September, 1954 .. ..
II	November-December, 1954 .. ..
	November-January, 1955 .. ..
III	January-June, 1955 .. ..

Soil type	Crops grown	Age at harvest
Navua	First crop	92 days
Tokotoko	First crop	75 days
Navua	First v. Second	49 days†
Tokotoko	Second crop	76 days
Navua	Second v. Third	143 days

† Series II with Navua soil was a very short-term crop.

In between the growing of one crop and the next, the pots were left unwatered : this resulted in the soil drying out and then remaining dry for a considerable period before being brought back again to the moist condition for re-planting. The whole of the three series of trials were carried out within a year, so Navua soil grew three crops within 12 months, although only the last crop was taken to the setting of grain.

* Actually calcium dihydrogen phosphate was used instead of commercial superphosphate in this trial.

RELATIVE YIELDS OF STRAW

Soil and crop	Series	No phosphate		Lau phosphate		Rock phosphate		Superphosphate	
		No nitrogen	With nitrogen	No nitrogen	With nitrogen	No nitrogen	With nitrogen	No nitrogen	With nitrogen
FIRST CROPS—									
Navua soil	I	100	107	344	220	563	476	597	924
	II	100	..	322	..	890	..	932	..
Tokotoko soil	I	100	116	217	303	..	..	547	604
Mean		100	112	294	262	726	476	692	762
SECOND CROPS—									
Navua soil	II	100	125	133	133	600	617	333	633
	III	100	..	210	..	351	..	374	..
Tokotoko soil	II	100	94	158	192	..	..	337	387
Mean		100	110	167	172	476	617	372	510
THIRD CROP—									
Navua soil	III	100	275	425	300	738	975	750	750
Mean of residual (second and third) crops		100	192	296	231	607	796	561	630
Mean of all crops		100	166	295	241	647	689	605	671

N.B.—All phosphate treatments led to much improved tillering, and this was the basic reason for the very large increases in yield which were recorded.

It is immediately clear that phosphate in any form has produced very large increases in growth under all conditions. The smaller response to Lau phosphate has already been dealt with in the preceding article in this Journal. The next general effect which may be noted is that nitrogen has produced no result comparable with that of the phosphates.

The third point of interest is the general similarity between the immediate effect of the fertilizers on the current crop and the residual effect on subsequent crops. This suggests that all phosphates whether soluble or insoluble can remain agriculturally effective in these padi soils for a considerable time. Independent observations (Cassidy—unpublished MSS.) have in fact, shown that fixation of phosphate is very low in Navua soil-type and not particularly serious in Tokotoko type.

The extremely large increases in growth that were obtained in these experiments are worthy of some remark. It is not usual that control plots should be outyielded manyfold and not just by a simple percentage increase. The fact that the plants were grown in pots without drainage made the loss of nutrients by leaching an impossibility, and this may have increased the effectiveness of the fertilizers. Continuous flooding of the soil followed by complete drying may have had some influence also, although the control plots received the same treatment and this situation did not apply to the first crops. It should be mentioned that for Series I and II the weight of straw was taken as a measure of growth, but in case the yield of grain might not match the vegetative growth, Series III plants were taken as far as the setting of grain. The weight of the seed heads was found to parallel that of the straw, and it was concluded that, in the earlier series, yield of straw would also have been indicative of yield of grain.

In a general way the two soil types responded similarly, the response to phosphate being large and consistent whilst the response to nitrogen was of a much lower order.

II. FIELD TRIALS

BY N. G. CASSIDY AND S. A. SINGH

The first evidence in confirmation of these results has now become available. A field trial was set out on Navua soil type at Nabukavesi in February, 1956. The treatment consisted of a top dressing with superphosphate at 200 lb per acre applied to New Guinea rice three weeks after transplanting. The plots were approximately 1/20 acre in size, and there were five controls and five treated plots in a randomized block. All plots had been bordered with check banks, so the rice was grown under flooded conditions.

Leaf roller was present in the crop but this experimental area was planted earlier than nearby crops and it not only suffered little damage from leaf roller, but it was harvested before a severe outbreak of cutworm (which followed flooding early in the year) had got under way. However, like all the rice crops in the district it was damaged by lodging; a considerable amount of grain being visible on the ground at harvest time. Due to the heavier seed heads, the plants of the phosphate plots showed more lodging than the controls. Harvesting for the purposes of the experiment was achieved by casting a hoop into the crop and carefully cutting all the plants which had their origin within the area of surface bounded by the hoop. Harvesting was at 100 days after transplanting.

	Grain Yield	Tiller count (at 40 days)	Stems per stool at harvest
Control	222 5	13	10.9
Phosphate	358.0*	102**	13.6
Significant at 5%	132 4	36	6.1
Differences at 1%	219.0	60	10.1

As in the greenhouse experiments the application of phosphate very markedly increased the number of tillers formed. At 40 days tillering gave an indication in advance of the ultimate yields, for the correlation coefficient between final yield (dry weight of earhead) and tillering (number of tillers at 40 days) reached the high value of 0.883. At harvest time there were 25 per cent more stems per stool in the phosphate plots and there was a 60 per cent increase in yield of grain; the latter was significant at the 5 per cent level.

(*b*) Another experiment incorporating the effect of flooding and of superphosphate in a factorial design was laid down nearby. This trial was planted later than the first one and the plants came into ear when the cutworm outbreak was at its worst whilst lodging was also severe. The crop was dusted with D.D.T. powder at 30 lb per acre and this saved the crop for harvesting, whereas nearby undusted crops were almost a total loss. However the increase due to flooding was only 20 per cent and the increase due to superphosphate with flooding 15 per cent, neither of these results being significant: superphosphate alone showed no benefit. It is proposed to repeat the experiment so that the treatments may be tested under normal conditions. At the same time a demonstration of the value of flooding (Cassidy and Singh, 1956) will be included.

CONCLUSIONS

The need of Navua and Tokotoko type soils for phosphatic fertilizer has been clearly shown, although a complete realization of the benefit from phosphates has yet to be achieved in the field. It has been indicated that these soils do not as yet need nitrogen.

The value of flooding has received some further confirmation; but a fresh trial for both flooding and superphosphate, under more normal experimental conditions, is planned.

Nevertheless, it is clear that both of our two main padi soils will respond well to controlled flooding and to the use of superphosphate. One of our main troubles is to get a rice variety that will stand up well under the added weight of earheads which the adoption of these methods can produce.

REFERENCE

Cassidy, N. G. and Singh, S. A.—(1956). The Importance of the Flooding of Rice. Fiji Agric. Journal, Vol. 27, Nos. 1 and 2, pp 6-10.

SEED RATE AND ROW SPACING IN DRILLED RICE

BY R. R. MASON

SUMMARY

The results of a series of experiments on seed rate and row spacing are described. Under the conditions described the optimum seed rate was 80 lb to the acre. There was no difference between row spacings of 7 and 14 inches, and therefore the latter is recommended since it simplifies the task of hand weeding.

The majority of the rice crop grown in Fiji is transplanted, and the rest is either drilled or broadcast. For example, in the 1952/53 crop, 57.4 per cent was transplanted, 32.8 per cent was broadcast, and 9.8 per cent was drilled. The term "drilled" is here used to include rice sown by hand in the furrow behind a plough. The advantage of this method over broadcasting lies in the simplification of hand-weeding the growing crop. Although many broad-leaved weeds of rice fields can be controlled by spraying with a selective weed killer, the worst weeds are grasses—Muraina grass (*Ischaemum rugosum*) and Para grass (*Brachiaria mutica*). Sensitive plant (*Mimosa pudica*) is also resistant to 2,4-D although 2,4,5-T is of some value, especially against young plants.

Good results have been obtained on both experimental stations from drilling rice with a grain drill; and where a crop rotation has been followed and a nitrogenous top-dressing applied, yields of up to 30 cwt. of padi per acre have been reached at Korinivia. Good preparation is essential to keep the subsequent weed growth to a minimum, and for this reason the use of a mould board plough is preferable to disc ploughing. If rain does not fall within a day or two of drilling, rolling with a Cambridge roll is recommended. It is sometimes difficult to judge the onset of the rainy season; drilling too early will result in poor germination and possibly a crop failure, while delay may mean that a long spell of wet weather gives no chance of drilling for several weeks. In general early December appears to be the optimum time.

There appears to be remarkably little published work on the optimum seed rate of drilled rice. A report from Madagascar states that 100-120 kilograms per hectare (89-107 lb per acre) were found to give the highest yields both of grain and of straw in direct sowing. This agrees closely with the results given below.

A series of trials has been carried out over four seasons in which four seed rates and two row-spacings were compared. The variety used was New Guinea. The seed rates were 40, 60, 80 and 100 lb per acre. A Massey-Harris-McKay "Sundrill" 8 coulter disc drill was used, in which adjustment to the rate is made by the use of different cogs and gear ratios. The drill is set to a row spacing of 7 inches; a second spacing of 14 inches was obtained by using only four coulters and putting two spouts into each. This ensured that the seed rate was unchanged.

Trials were carried out in three seasons at Koronivia in the wet zone, and in one season at Sigatoka in the intermediate zone (in 1953/54). The second season's trial, at Koronivia, suffered from poor germination due to a dry spell after drilling and gave the very low average of $7\frac{3}{4}$ cwt. of padi per acre. The results are given in Table I. In no year was there any significant difference between the row spacings of 7 and 14 inches. A seed rate of 80 lb per acre gave the highest yield on three occasions out of four, the fourth being the very poor crop already referred to. The yields from 80 lb of seed were significantly better than from 40 or 60 lb on one occasion, and from 40 lb on the average of the four trials.

YIELDS OF PADI IN HUNDREDWEIGHTS PER ACRE

Year	Spacing	Seed Rate (lb per acre) 40	60	80	100	Mean	Sig. Diffs. 5%	1%
	7	18.02	18.68	22.13	20.68	19.96		
1950-51	14	19.80	19.25	22.45	20.93	20.61		
	Mean	18.92	18.97	22.29	20.81	20.24	3.13	4.26
	7	7.73	9.68	7.23	8.08	8.18		
1951-52	14	8.43	6.35	7 95	7.15	7.47		
	Mean	8.08	8.02	7.59	7.63	7.81	N/S	
	7	17.74	17.32	19.34	18.54	18.24		
1953-54	14	13.46	19.34	18.32	17.72	17.21		
	Mean	15.60	18.33	18.83	18.13	17.72	N/S	
	7	10.58	10.82	12.08	12.22	11.43		
1954-55	14	10.02	10.84	11.82	11.38	11.02		
	Mean	10.30	10.83	11 95	11.80	11.22	N/S	
	7	13.59	14.12	15.25	14.93	14.47	1.73	2.29
Mean	14	12.77	14.07	15.13	14.32	14.07	1.73	2.29
	Mean	13.18	14.09	15.19	14 63	14.27	1.22	1.62

The recommendation is therefore made that a row width of 14 inches should be used to allow for easier hoeing, and that a seed rate of 80 lb be used for good seed of New Guinea or a similar medium-term variety.

REFERENCE

Inspection Generale des Services Agricoles Recherche agronomique de Madagascar No. 1. Compte rendu 1952 (Field Crop Abstr. 1954 No. 731).

ANIMAL HUSBANDRY . . .

POULTRY MANAGEMENT AT KORONIVIA

BY R. R. MASON AND J. R. CAMPBELL

The importance of the poultry industry to Fiji lies not only in the production of eggs, but also in the production of meat which is acceptable to all; for the large Hindu section of the community does not eat beef and the Muslims do not touch pork.

Table poultry sells at 3s. 9d. to 4s. per pound, undressed. The majority is curried, and so there is little or no price difference between fat young cockerels and old hens. This demand for meat is an argument in favour of heavy breeds, and most back-yard poultry keepers do in fact prefer Rhode Island Reds or Australorps. White Leghorns however give both a greater and a more even production of eggs throughout the year, and they are chosen by most who run poultry on a larger scale. Seasonal variation in production is always great, February and March being the worst months (during which eggs are imported from New Zealand) and August being the time of a glut ; there is no large cool store, and prices range from 3s. 6d. up to 8s. 6d. a dozen.

Poultry in Fiji is on the whole remarkably free from diseases. Coccidiosis is fairly common in chickens and can cause heavy losses. Roup and allied diseases occur to some extent in adult birds and cases of fowl paralysis have occurred. Gape worms, intestinal and caecal worms also occur but do not cause serious trouble.

In view of the high prices of eggs, back-yard poultry keeping is popular. There is no regular supply of young pullets for sale, and there was no commercial hatching until the Department commenced operations at Koronivia in 1953. Day-old chicks are imported each year from both Australia and New Zealand, and these figures, together with sales from Koronivia, are shown in Table No. 1. Production at Koronivia has been to the limit of the incubator, but the demand is not nearly satisfied. Hatching is confined to the months June to September inclusive, since earlier hatched pullets tend to go into a moult in February, and later-hatched birds grow more slowly because of the hot weather.

TABLE I

SALES OF DAY-OLD CHICKS

Origin	1951	1952	1953	1954	1955
Australia ..	19,814	9,960	10,250	7,636	11,887
New Zealand ..	2,075	1,391	5,877	3,346	2,848
Total Imports ..	21,889	11,351	16,127	10,982	14,735
Koronivia ..	..	..	785	9,043	9,746
Total chicks ..	21,889	11,351	16,912	20,025	24,481

KORONIVIA FLOCKS

The principal aims in the work being carried out are flock improvement by the selection of the best strains, and production of day-old chicks for sale. At the same time information on feeding, hatching, rearing and so on is being acquired. Up to the present year, three breeds have been kept in roughly equal numbers, and comparisons have been possible ; but it is now intended to concentrate on one breed with undivided effort in order to carry out a worth-while breeding programme.

The first birds were brought on to the newly established Principal Agricultural Station at Koronivia in 1949. In that year foundation stock of two breeds (White Leghorn and Rhode Island Red) was obtained from New Zealand, and small flocks kept for some years. More White Leghorns and some Australorps were obtained from Massey Agricultural College in 1952. The Rhode Islands produced poorly in that year and also there were a number of cases of fowl paralysis ; next season an Australian strain of cockerels was used, resulting in considerable improvement. A few Light Sussex were obtained locally in 1955 ; they were of an Australian strain. Further settings of White Leghorn and Rhode Island were obtained from Massey Agricultural College in the same year.

Expansion of the flocks began in 1953, following the initiation of a breeding project and the building of new houses. A start was made with the production of day-old

chicks for sale, using small Kerosene incubators ; hatching results however were very poor until a 4,000 egg electric " Gamble " cabinet incubator was installed towards the end of the season. This is used for the production of chicks for sale, and also for chicks for flock replacement and to a limited extent for custom-hatching of customers' eggs.

The present capacity is for about 700 birds, kept semi-intensively. This is made up of 14 breeding pens, being seven double houses carrying 11-12 birds on each side ; and three double and four triple pullet houses, designed for group-testing groups of 30 pullets. All houses have concrete floors and dwarf walls, and are sited with open fronts to the west and corrugated iron roofs falling to the east, since most of the rain is brought by the south-east trade winds. The walls of the breeding-pen houses were made of the local soft-wood *Kauvula* which on the whole is standing up to the weather but needs frequent creosoting. The bure houses with two pairs of pens cost £60 each in 1950, and house 20-24 birds. The first double-unit pullet house, for a total of 60 birds, cost £186 in 1953, but simplification in the design of the next two reduced the cost to £152. Asbestos-cement sheets were used for the walls in these houses ; in the next four a double wall of woven bamboo was employed, and with speedier building the cost was kept down to £175 for 90 birds. (Besides the gates and netting for pens, this includes built-in dry-mash hoppers).

The allowance per bird is 2⅔ square feet of house and 70 square feet of run. Earlier experience with 50 square feet showed that grass could not be maintained. Two runs are provided for each house so that one can be rested while the other is in use. Even so, the only useful grass that will persist is couch (*Cynodon dactylon*). The tufted crows foot (*Eleusine Indica*) is a weed grass which is difficult to control. Deep litter is used in all the houses ; wood shavings with a little rice " bran " (really rice hulls) are used, and prove very satisfactory. Rice " bran " alone becomes too compact. The litter is forked over occasionally, and easily lasts for a year so long as it does not get wet.

FERTILITY

Infertility was a very serious problem in 1953. There were very big differences between the best and the worst cockerels ; that this was mainly due to inherited factors is shown by the fact that fertility has been greatly increased since that year by selecting cockerels on the fertility record of their sires. Also the use of young birds in preference to old cocks appears to have helped. Table No. 2 shows the fertility for different breeds in different years. The improved fertility in the Australorps is particularly noticeable.

TABLE 2

PERCENTAGE FERTILITY

Breed	1953 Mean	1954 Hens	1954 Pullets	1955 Hens	1955 Pullets
White Leghorn ..	80.6	93.5	94.0	93.9	93.8
Rhode Island Red ..	88.5	97.4	95.7	96.5	97.0
Australorp	59.8	88.5	87.1	92.0	92.0

It should be noted that the hens are in pens of 11 with one cockerel while the pullets are in groups of 30 with three cockerels.

Comparisons between young cockerels and old birds in 1953 were based on very small numbers of eggs but older birds show a decrease in fertility in most cases.

TABLE 3

COMPARISON OF FERTILITY BETWEEN COCKERELS AND OLD COCKS IN 1953

	Number of eggs	Number of cockerels	Percentage fertility
White Leghorn—Young ..	95	3	78.9
,, Old ..	2,060	5	80.7
Australorp— Young ..	217	4	78.4
,, Old ..	1,186	4	64.4
Rhode Island—Young ..	288	2	92.0
,, Old ..	524	3	87.2

Table No. 3 shows that most young cockerels were better than old cocks. Figures for individual birds in two seasons show a mean decrease of percentage fertility of 5.6 per cent for five White Leghorns (of which four decreased and one increased) ; four Australorps showed a mean decrease of 7.3 per cent, three decreasing and one increasing, and four Rhode Islands showed a very slight mean rise of 0.5 per cent, two having increased and two decreased. These figures are of course based on very small numbers. Probably of more importance than infertility is the greatly increased mortality in the second season in the Australorps and Leghorns, the Rhode Islands appear to have better stamina.

Eggs for incubation are kept up to a maximum of six days. They are stored in a cool building on a shelf covered with rice bran, and are turned daily. Air temperatures in July range from 59° to 89° F.

INCUBATION

Hot-air Kerosene incubators were used until 1953 but results were poor—60.1 per cent of fertile eggs were hatched in 1952, and 44.4 per cent in 1953. In the latter year one reason, discovered part-way through the season, was that several of the ventilation passages inside the cabinet were blocked by mud-wasps. This had the effect of reducing ventilation ; the carbon dioxide content of two machines on the 18th day was found by the Chemistry Section to be 0.6 per cent and 0.4 per cent which is unduly high. Cleaning the passages and covering the holes with mosquito gauze gave considerable improvements. Although it was not fully tested there were indications that a temperature of 102° F. was more suitable than the standard 103° F. Undoubtedly however the greatest trouble was caused by fluctuations in temperature, which sometimes exceeded 3° F. and emphasized the necessity for skilled attendants.

TABLE 4

INCUBATION RESULTS

Year Incubator	No. of eggs set	Percentage of total eggs hatched	Percentage of fertile eggs hatched
1952—Kerosene ..	3,339	49.0	60.1
1953—Kerosene ..	2,715	34.8	44.4
1953—Electric ..	1,550	59.9	79.3
1954—Electric ..	17,769	75.2	81.4
1955—Electric ..	18,704	71.6	76.9

The electric incubator has the advantages of accurate temperature control, forced draft, and easier turning. An alarm device has been fitted to ring an electric bell in case of power failure or voltage drop. It consists of a centrifugal governor on the end of the fan-shaft, and it closes a contact if the fan speed falls. It has proved its value on several occasions. One of the advantages of this make of incubator is that setting and

Chicks being removed from the 4000 egg incubator.

Day old chicks being packed for despatch.

hatching compartments are separate and can therefore be maintained at different humidity —47 per cent for setting and 70 per cent for hatching.

The economics of incubating chickens for sale show that with eggs charged at 5s. per dozen and unsexed chicks sold at 1s. 6d. each, a profit of £347 was made in 1955 though selling 9,746 chicks. Costs of labour, of eggs, of electricity, and of depreciation on building and machine have been included. A similarly satisfactory figure was obtained in 1954 ; indeed, the machine paid for itself in that first year.

BROODING

Cold brooders in which the chickens' own heat is conserved by strips of blanket hanging down from the lid of a brooder box, were formerly used in conjunction with runs floored with wire netting and raised three feet off the ground. The brooder boxes were placed inside a building and the chickens ran through a hole in the wall to reach the run outside. Results were very poor. The effects of exposure to wind were reduced by bringing the runs down to a couple of inches above ground level and building wind breaks. Overcrowding in wet weather was eliminated by providing an inside run. Boredom and resulting cannibalism were reduced by providing deep litter in this run, to encourage scratching. This system is being followed with very good results by the Methodist Mission's Navuso Agricultural School. However, losses from overcrowding in the corners of the brooder boxes were still being experienced at Koronivia, so floor-brooding on deep litter was instituted, with conical brooders heated by a 60 watt electric lamp bulb ; for night temperatures can fall to below 60° F. This system is giving good results. Total losses

Chicks in deep litter. Notes—1. Brooder upended to show construction; 2. Automatic feeding hopper on left; 3. Self filling water trough left background; 4. Exit to outside wire floored run in middle background.

in the brooder house last year were 7 per cent, and would have been less if more reliable labour had been available. Coccidiosis was troublesome at times but was controlled by the use of " Nefco ".

The construction of the brooders is shown in Plate 3. The pens hold about 120 chicks comfortably to five weeks, allowing a little over two thirds of a square foot of deep litter per chick. (With larger numbers per pen, uneven growth and cannibalism have occurred). After two weeks the chicks are allowed to run out to an outside run which adds an extra one third of a square foot ; but the outside run, with a wire netting floor, is not nearly as popular as the inside one. The lamp is switched off after four weeks, and later on the brooder is lifted up to harden the chickens off.

Baby chicks are confined around the brooder for the first two or three days. Their first feeds are of rolled oats plus dried milk powder (five to one). This lasts for four days, after which they feed from dry-mash hoppers. (See figure 1). One feed of wet mash incorporating skim milk is given each morning. Chopped para grass (*Brachiaria mutica*) is given as green feed, and is eaten eagerly. A plot of Ramie (*Boehmeria nivea*) has been established for feeding next season. This is reported by Squibb from Guatemala to be very high in both protein and riboflavin. It will also be fed to the breeding stock.

The water-trough shown in Plate 3 had only just been installed and had not then been fitted with a grill and drip-tray. The tap is operated by the weight of water in the trough in such a way that it fills the trough when it is empty and cuts off when it is full.

The radii of the two cones of the brooder are 23 inches and 19 inches ; they are made in two halves and rivetted together, and from each half an arc 6 inches or 5½ inches respectively is cut off, in order to form the cone. The edges of the completed cones are rolled down over a ring of eight S.W.G. wire to give a strong finish. Three small brackets hold the inner and outer cones about two inches apart, and three other brackets serve as legs.

REARING

Heavy losses have on occasion been caused since shortage of proper housing necessitated an unsuitable building being used ; whenever supervision was even slightly lax, trouble arose from overcrowding and suffocation. Mongoose trouble was also frequent as these pens are not on flat land which can be kept mown short. The slopes were most unattractive to the chickens. A change was made at the end of last season, the chicks being moved straight from the brooder house to slatted-floor arks, and this has proved very successful. The growing birds are held in these arks until they are transferred to the laying houses. The arks are of very simple construction ; 3 by 2 inch timber is used to make three triangular frames, bolted at the corners, and these three frames are spaced apart by three purlins on either side which carry the corrugated iron sheets of the roof. The ends are normally left open but are covered with bags if necessary in cold windy weather. By December however the problem of keeping cool is more important, and the arks are raised about twelve inches on legs made of galvanized iron pipe. These arks have a floor space of 8 x 5 feet ; 10 sheets of corrugated iron (five feet long) form the roof. The cost is about £6 per ark, and they carry up to 100 chickens at six weeks or about 20 full grown birds.

LAYING STOCK

The latest type of house to be built for the laying stock was designed to hold three groups of 30 birds each, for group progeny testing, and is therefore more complex than would be necessary for commercial laying houses. The walls are formed of two sheets of woven bamboo ; this is sprayed regularly with creosote and is proving quite satisfactory. Tunnel nests are used to obviate the overcrowding which commonly occurs in partitioned nests ; another advantage is that the nesting place is darker and more attractive to the hens. A strip of wire netting along the side prevents the box becoming too hot. The built-in dry-mash hoppers can be filled from the outside of the building. Another and slightly different type is shown in cross section in Figure 1.

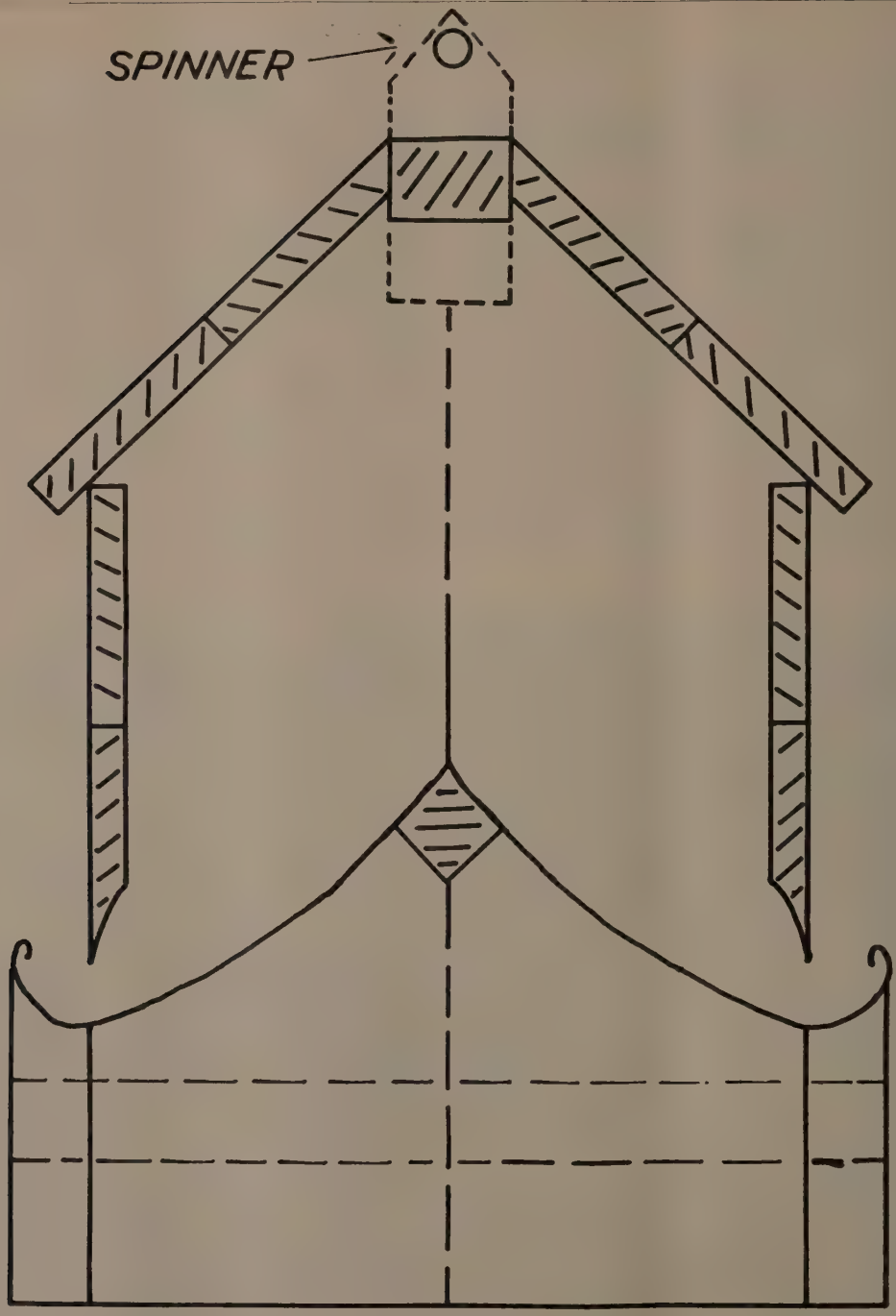

Figure 1.

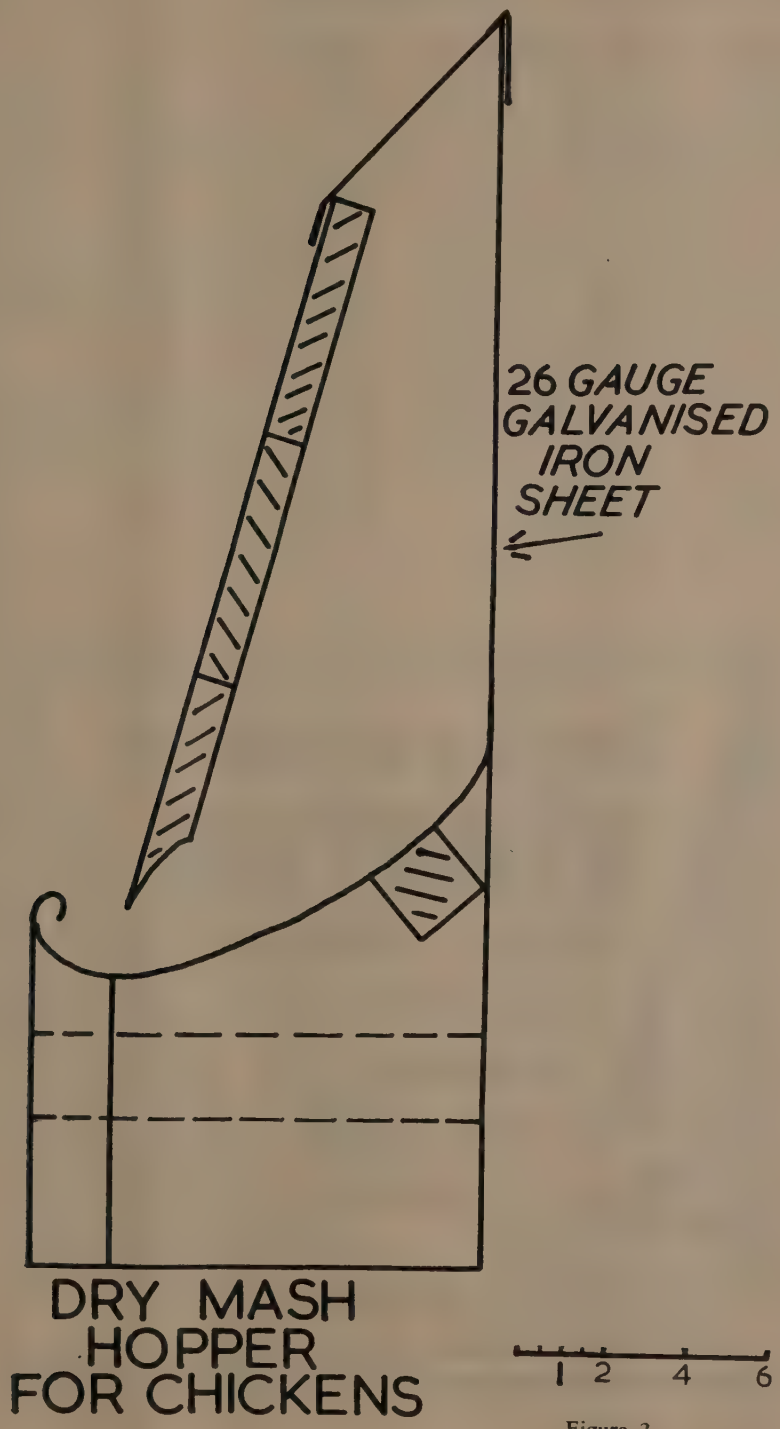
26 GAUGE
GALVANISED
IRON
SHEET
DRY MASH
HOPPER
FOR CHICKENS
1 2 4 6

Figure 2.

The dry-mash self-feed hopper type of feeder is excellent for chicks, provided that it is designed to prevent the mash from clogging. The trough proper should be fitted with a lip to prevent the chicks pecking out the mash. Chicks delight in climbing over them, and if possible they will get into them and scratch among the food, fouling it with droppings. Many self-feed hoppers are unsatisfactory because the hopper is wider at the top than at the bottom; consequently, the mash clogs; and the trough itself may be empty while the hopper above it is almost full. Some hoppers alleged to be of the non-clog design require the services of an attendant to unclog them at least once a day. The sides of self-feed hoppers should be vertical, or even a little wider at the base than at the top.

Troughs should always, as far as possible, prevent contamination and waste. A perch is made of $\frac{3}{8}$ inch round mild steel and is carried through the inside of the hopper, being pivoted where it passess through the end walls of the hopper. The inside part is given a slight twist, so that its movement breaks up the meal which otherwise tends to arch across the hopper. The perch is supported by rubber bands cut from old motor car inner tubes.

To prevent the chicks from roosting on the top of the hopper, and fouling it with droppings, a spinner or revolving bar is attached, running along the centre over the roof of the hopper.

TUBERCULOSIS

BY H. HARDIE

Most people are aware of the enviable situation in Fiji with regard to disease problems concerning the productive animals—these animals being cattle, pigs and goats. Horses may be brought into the picture more indirectly since they contribute a great deal to production by work, be it for draught or riding.

Apart from the fact that our temperatures, whilst sometimes high, seldom become excessive, the food of cattle, goats and horses here is almost entirely herbage, which is their natural food, and provides all the necessary vitamins, proteins, etc. No housing or unnatural feeding is required, unless we count the milking bail and the giving of supplementary feeding respectively.

For pigs, even though they are kept on concrete to curtail losses due to kidney worm, there are plenty of root crops and fruits to feed them. There may be some difficulty in obtaining regular and economic supplies of animal protein necessary for best results, but this is not an insurmountable obstacle.

Digestive and metabolic upsets then, cannot be blamed for any considerable lack of improvement in production. Major diseases are remarkably absent, with the single exception of tuberculosis, and this disease is widespread, and is probably the greatest single cause of loss of production from animals.

In this paper it is proposed to consider only cattle and the loss of milk and beef must add up to many thousands of pounds annually. This loss is very real, and only its unobtrusive beginnings and slow progression masks the continuous drain on the Colony's economy for which this very infectious and deadly disease is responsible. One cannot help feeling that if the onset of disease were soon followed by a remarkable fever and quick, sure death, then all possible resources would be diverted to tackling and overcoming the cause. Instead this unspectacular disease continues daily to drain off the possible increased production in all parts of the Colony, with this draining off being more pronounced in the wet zone.

In cattle, infection can be spread to new cases by ingestion or by inhalation of the causal organism *Mycobacterium tuberculosis*, of which there are five strains. Only the true bovine strain and the human strain are of importance in Fiji. Spread by ingestion is probably the more important. Infection generally starts up in the lymph glands of the head, the lungs, or the intestinal lymph glands. Other sites may be involved, but generally this is brought about by blood spread. The three common sites of infection give the following clinical pictures :—

(1) *Lymph Glands of Head*—Enlargement and hardening of the affected glands takes place, and this can often be noticed around the throat, or felt quite distinctly on examination. " Snoring " is often caused by partial blockage of the respiratory passage.

(2) *Lungs*—Infection is here set up by inhalation—as by contaminated dust particles, etc.—or by way of the blood stream. Generally spread along the bronchioles occurs, giving bronchial pneumonia. In some animals where progress is slower, a fair amount of encapsulation may occur, and this results in a typical " tubercle " being formed, containing a sort of cheesy pus, the whole lesion being fairly readily recognized on post mortem examination. Some animals seem to be more resistant than others in that this encapsulation is more marked, and the rate of progress of the disease consequently slowed down. Although this slowing down may be definitely marked, it seems very unlikely that any lesion once established can be completely encapsulated and halted if the organism causing it is the true bovine strain. Quite frequently in other countries another aspect crops up because human and avian strains of tuberculosis organism may also affect cattle, and it seems that infections due to those strains may be overcome. However, avian strain is not present in Fiji, so far as we know, and the importance of this cross-infectivity

therefore concerns only human strain, and infection of cattle by this one is fairly uncommon.

(3) *Intestinal Glands*—It is probable that all cases shown arise from the ingestion of infected materials which sets up a lesion on the intestinal wall, and spread then occurs to the lymph gland. The intestinal lesion meanwhile disappears. The general picture shown by infected cattle is one of indefinite indigestion and usually unthriftyness later on. It is difficult indeed to pick out an animal with intestinal infection.

CULLING AND CONTROL

The aim of all stockmen should be to eradicate tuberculosis altogether so an attempt will be made to give some indications of the main signs shown by tubercular animals and to give some ideas on detecting those animals. Without testing, eradication is wellnigh an impossibility and even with it, good control seems to be difficult at times.

Possibly about the most reliable of the features to pick on is the enlargement and hardening of the superficial lymph glands, particularly of those around the throat. Other causes of swelling of the glands usually show more swelling of surrounding tissue, and the glands themselves are usually softer. Snoring cattle should be strongly suspected.

Tubercular pneumonia gives a soft, sibilant but persistent cough and this can be a very useful indication. Lung cases generally take on a poor appearance fairly soon, and this extra guide should be sufficient to confirm diagnosis. With some training and practice the chest sounds can be used as a good aid in thoracic infection.

A good deal of sputum may be coughed up and from this it is possible to prepare microscope slides which can be very positive aids in diagnosing tuberculosis, because the organism may be present in large numbers in the sputum. A sample can be collected and taken to a laboratory for examination if necessary.

Cases of indefinite poorness coupled with a starey, long-haired coat are very suspicious. These are possibly cases of intestinal tuberculosis. Unexplained poorness following calving or other upset may be due to tuberculosis, and cattle have been known to show falling-off after successive calvings and then show tuberculosis on post mortem. It seems then that in some cases at least, even advanced infection may last for a year or two. Such animals are liable to be serious causes of contamination of pastures, troughs, etc.

Cows having udders with lumpy hard areas that keep on increasing, or with quarters showing gross general enlargement, are very likely cases of tubercular mastitis. The milk secreted by infected quarters may be only very slightly altered until the case is far advanced, and it then becomes straw coloured. All the while large numbers of the organism are being excreted, and if such milk is fed to calves or pigs or to children, widespread infection may result. The organisms are fairly readily detected in milk samples.

In order to increase production from cattle, all suspicious animals should be culled. It may seem a hard thing to do, but it is much better to cull out vigorously in the first place than to allow this deadly disease to go on taking its yearly toll, and with regular care it is often quite possible to keep tuberculosis at a low level.

Here again briefly are the suggested reasons for culling, but it should be borne in mind that practice helps a lot, coupled with consideration of the herd history.

(1) Hard swelling of one or more lymph glands.
(2) Persistent, sibilant, characteristic cough, if in doubt try to obtain sputum sample.
(3) Indefinite indigestion.
(4) Poor, starey coat with hard, tight skin.
(5) Hard, chronic, gradually increasing swelling in the udder.

Remember that no system of culling is completely reliable and may be quite far from it, but with keen interest, intelligent observation and regular inspection and culling, the above suggestions will help enormously in curtailing the losses caused by this scourge. Even if testing is carried out this clinical culling must still be combined with it to try to eliminate non-reactors.

PLANT PATHOLOGY . . .

NOTES ON PLANT DISEASES LISTED FOR FIJI

BY R. B. MORWOOD

These notes have been prepared as a supplement to "A Preliminary List of Plant Diseases in Fiji" in order to indicate the importance of the various diseases. Brief reference is made also to the measures taken to deal with a number of them.*

Banana—Banana leaf spot—also known as Sigatoka disease—is the most prevalent serious disease in Fiji. Losses due to this disease are large but very difficult to estimate owing to the many other factors such as soil fertility, weed control and pruning which are seldom maintained at optimum status. The fungus *Mycosphaerella musicola* causing the disease, results in a loss of leaf amounting commonly to half the leaves in growing plants and frequently leading to the loss of all leaves prior to maturity of the bunch. The loss of leaf, in turn, produces a loss of vigour, hence smaller bunches. What is even more serious is that the loss of leaf in the late stages interferes with the development of the fruit which may not be detected when the bunch is harvested but which prevents correct ripening. The disease can be controlled by spraying but it is difficult and expensive to apply adequate control measures and they are frequently entirely neglected. Investigations are in progress to get more information on spray control. The ideal of control by the use of a resistant variety is as yet unattainable.

Other diseases of the banana causing spots on the leaves include rust, diamond spot and black cross spot, but they are of minor importance compared with leaf spot. Speckle is fairly general and may be of some consequence. It is readily confused with red spider injury.

Panama disease, *Fusarium cubense*, has been recorded from Fiji but was not found by the writer. The cultivation of susceptible varieties has practically ceased and they are now found only in small isolated plantings.

Anthracnose is found extensively on ripening fruit either following bruising or as a stem end rot spreading from an infected bunch stalk. *Nigrospora sphaerica* can be readily found on necrotic banana plant parts but squirter disease is not prevalent.

Bunchy top takes a continuous toll of bananas in Fiji. Counts of plants needed to be taken out and replaced on experimental plots indicated a loss of 5 per cent of stools per annum. As it takes the replacement twelve months or more to come into bearing, the loss of crop due to bunchy top can be taken as approximately 5 per cent. This represents £15,000 off the export crop for the colony. The disease is kept under control by eradication of diseased plants but a more concentrated effort would ultimately reduce losses.

Beans—Isariopsis griseola on French beans and *Cercospora cruenta* on long beans and Mauritius bean are generally present on all older leaves. These diseases limit the cropping life which tends to be therefore short—particularly in the case of the French bean. During wet periods cottony rot, *Sclerotinia sclerotiorum* defoliates many legumes. Its attacks are lethal to French beans. No control measures are practised on beans.

Breadfruit—None of the fungi recorded from breadfruit was found by the writer to cause any serious disease.

Cabbage—White rust, *Cystopus candidus*, is quite common on both cabbage and chinese cabbage, but control measures are seldom required. Three bacterial diseases have been recorded of which *Pseudomonas maculicola* is the commonest, but losses are negligible.

* Morwood, R. B.—1956, Fiji Agr. J., Vol. 27, pp. 51-54.

Cacao—Of the parasitic fungi, *Botryodiplodia theobromae*, is the one most frequently found on cacao in Fiji. It causes a pod rot and is found associated with seedling dieback and root rot. Black pod, due to *Phytophthora palmivora*, has been recorded but no definite instance of this disease was found by the writer. The fungus, which also frequently induces serious fruit and root rots of pawpaw, was found causing seedling blight in cacao nurseries. The question of the amount of loss due to black pod in Fiji will be more readily determined when the trees from the present extensive plantings come into bearing. The demonstration block of cacao now bearing at Naduruloulou is regularly sprayed with Bordeaux mixture which would ensure a low incidence of the disease in that particular block.

An undetermined thread blight is commonly present on old neglected cacao, but is not expected to be serious in well managed plantations. The most serious virus and some fungus diseases of cacao are fortunately absent from Fiji and no effort should be spared to maintain that freedom.

Carrot—Bacterium carotovorum causes heavy loss in carrots in the warmer months. The only feasible control is to avoid planting at that period. Losses of plants in the cooler months are usually due to *Sclerotinia sclerotiorum*. The activities of this fungus can be minimized by avoiding planting in damp situations or overwatering the crop.

Cassava—Cassava is invariably affected with leaf spot due to *Cercospora henningsii* but it affects only the older leaves and is not considered to be of economic importance. No other parasitic diseases of this crop have been encountered but various chlorotic leaf conditions are found. Most of these are varietal but readily recognized by the regular patterns produced, but in some instances chlorosis is due to iron deficiency. The virus disease mosaic is not present.

Citrus—Citrus canker, caused by *Xanthomonas citri*, is a recent invader which finds conditions ideal for its spread in Fiji. Compulsory eradication of thousands of affected trees has not, as yet, rid the Colony of the disease. Eradication continues with mounting difficulties as the disease is discovered in more distant islands of the group and in citrus which has spread from cultivation into the jungle.

Scab is widespread on lemons and mandarins and, in the absence of a well organized citrus industry, little is done to control the disease. Control by sprays would be difficult on the wet side of the islands where trees are liable to make new growth at any time of the year.

Dieback and decline of citrus is common wherever drainage is impeded. This becomes more severe in seasons of above average rainfall. No investigation has been made into the organisms associated with the roots and crowns of affected trees.

Coconut—Bud rot due to *Phytophthora palmivora* is the major parasitic disease of coconuts in Fiji but its damage is small compared with that due to various insect pests. Bud rot has been seen killing all trees of Malay dwarf coconuts planted in a high area where mountain mists favour the spread of the disease. Local tall coconuts in the same area were not affected. Young coconuts of all varieties are liable to "leaf cut" symtoms which are presumably due to a milder development of the same disease. These leaves are frequently submitted as suspect rhinoceros beetle injury, but the damage is quite distinct.

The various leaf spots are universally present and, in some situations, may have a serious adverse effect on the palm. Nothing can be done to control them. Thread blight is a serious disease fortunately seldom found.

Stem bleeding with which is associated *Ceratostomella* sp. is common following injuries or fires. Control is attained by avoidance of the primary cause.

The most frequent cause of death of palms in Fiji is lightning injury.

Coffee—Past records indicate that a coffee industry in Fiji in the past was destroyed by rust—*Hemileia vastatrix*—and that one attempt to revive the industry was rendered futile by the same disease. Rust is present on coffee now but not in an amount such as would be necessary to menace the industry. It is suspected that there were other factors

involved in the decline of coffee growing. At any rate, rust is readily controllable by copper sprays and fear of this disease should not prevent revival of coffee growing.

Other leaf spots are of minor importance and thread blight is a little more serious.

Cotton—Cotton growing has been abandoned in Fiji and the records of disease on the crop are of historic interest only.

Cowpea—Leaf spot due to *Cercospora cruenta* is generally present and frequently serious on this crop.

Cucurbits—Powdery mildew limits the life and production of pumpkins and cucumbers while anthracnose is the worst disease of water melons.

Dalo—The serious taro disease which is due to *Phytophthora colocasiae* was not found by the writer and is considered to be now not present in Fiji. The *Cerospora* leaf spot is generally present but confined to older leaves. A peculiar distortion and dwarfing of young leaves occurs occasionally. This trouble has not been identified. Recovery is spontaneous which suggests an accidental occurrence such as wind injury.

Egg-plant—Leaf spot of egg-plant frequently reaches serious proportions and warrants control by spraying with cuprox at frequent intervals.

Gerbera—Septoria gerberae is a regular parasite of this plant and for best performance gerbera plants should be sprayed with cuprox.

Granadilla—This crop, which deserves greater attention in Fiji than is given it, is subject to brown spot due to *Alterneria passiflorae*. The spots appear to do little damage but on the fruit the deeply cracked spots are both a direct loss and are liable to be followed by rotting of the fruit.

Lettuce—Leaf spot due to *Septoria lactuce* can be found on lettuce grown under poor cultural conditions. Control could generally be attained by the use of adequate fertilizer.

Maize—Two serious diseases of maize affect the crop in quite different manner. Downy mildew (*Sclerospora sacchari*) affects a small proportion of the plants, affected plants being usually a complete loss. Rust affects all plants but affected plants are only a partial loss. In fact, when rust is confined to the older leaves, the reduction in yield is not appreciable. The different incidence of the diseases is reflected in different control measures. To prevent the spread of downy mildew, each affected plant should be carefully removed and burnt or buried. To prevent the spread of maize rust, successive crops should not be planted nearby at intervals of only a few weeks. That is to say, the whole of any district should be planted at the same time, and the crop remains ploughed in before the next crop is grown in the vicinity. Rust frequently seriously reduces the production of maize.

Mango—Anthracnose of mango is normally present on leaves, inflorescences and fruit. This disease causes a total fruit drop whenever conditions are wet during the flowering season. It is therefore exceptional for the mango trees to bear fruit on the wet sides of the islands.

Pawpaw—Root rot of pawpaw (*Phytophthora palmivora*) is very serious in the wetter parts of the Colony. Even in the dry area on comparatively well drained soils, it only needs a few abnormal rains in the "dry" season, followed by the usual wet season, to result in loss of most pawpaw plants. In wet sheltered positions, the *Phytophthora* forms a "downy mildew" on the fruit, followed by fruit rot.

Para Grass—Grey spot and rust can frequently be found but do no appreciable injury to this valuable grass. An undetermined thread blight is also found but is of no particular consequence.

Peanut—Peanuts are grown on a small scale and the three diseases recorded do not have any serious effect on the crop.

Pineapple—With the closing of the pineapple cannery and consequent cessation of large scale growing of this crop, the diseases will become of little consequence. Both top rot and base rot take their toll of plants but neither has assumed serious proportions in the porous soils used for pineapple growing on the dry side of Viti Levu.

Potato—Heavy losses in potato crops are caused by both Fusarium wilt and bacterial wilt and also possibly by other undetermined wilts. Control is difficult and, next to banana leaf spot, potato wilt is the disease complex most urgently in need of investigation.

Rice—The most conspicuous disease of this extensively grown crop is false smut caused by *Ustilaginoides virens*. This disease is allied to the ergots rather than the smuts and cannot be controlled by seed treatment. It has been known to affect as much as 10 per cent of the heads but this is exceptional.

Leaf spot due to *Helminthosporium oryzae* is commonly present on dry land rice but only becomes serious on poorly grown crops, hence control measures consist of adequate cultivation and fertilization.

Piricularia oryzae can frequently be found as an innocuous leaf spot but the serious blast caused by this organism is rare.

Rubber—The large number of pathogens reported in the past from this crop are now of academic interest only, owing to the abandonment of cultivation of this crop.

Sugar—The diseases of sugar cane have received careful attention from plant pathologists employed by the Colonial Sugar Refining Company and in spite of the large number recorded, only a few are of major concern. Fiji disease and downy mildew are prevalent but kept under control by rogueing gangs employed by the company. Ratoon stunting is causing some concern and hot water treatment is being instituted. A " yellows " is proving to be a physiological disease and still under investigation by the company which, in addition to its activities in disease control and investigation, has an active plant breeding programme in which disease resistance receives major attention.

Sweet Potato—Apart from storage rots and a mild leaf spot, sweet potatoes appear to be free from disease. A suspected mosaic was later determined as thrip injury.

Tea—The writer did not make any observations on diseases of this crop which is only represented by a few plants in Fiji.

Tobacco—*Cercospora* leaf spot of tobacco is widespread and, while it is of little consequence whilst the crop is being converted to the local type of tobacco, it would need more consideration if a quality product is to be produced.

Mosaic seriously reduces yields and its incidence could be reduced considerably by elementary care in the production of the crop.

A disease of the black shank type occurs frequently—its etiology still requires elucidation.

Tomato—Bacterial wilt and leaf mould both make tomato growing in Fiji a hazardous project. Leaf mould can be controlled by spraying, cuprox being probably the best spray as it also controls the *Septoria* leaf spot which can also be quite serious. For leaf mould alone shirlan is the best fungicide. Bacterial wilt cannot be controlled by sprays and work on resistant varieties suitable to the different zones in the Colony is required. Varieties also resistant to leaf mould would be highly desirable.

Yam—Anthracnose of yam is at times serious but as a rule this crop can be grown without any concern for plant disease. The presence of various storage rots indicates the need for care in handling the harvested product.

Zinnias—Zinnias and many other compositious garden plants are frequently severely affected with powdery mildew. Spraying with cuprox or dusting with sulphur readily controls this disease.

BOTANY . . .

CASSAVA VARIETIES IN FIJI

BY R. R. MASON

SUMMARY

Sixteen varieties of cassava are described, together with the results of four variety trials from which it is concluded that the variety *Vula Tolu* is the most useful early maturing variety.

Cassava has now become a very important food crop in Fiji, the acreage in 1954 being estimated to be 16,050 which is almost exactly half the total acreage of root crops (1). The average yield is probably about five tons to the acre, and at a price of £12 per ton on the farm the crop is worth over £100,000.

Cassava is native to tropical America and was first spread to other parts of the tropics by the Portuguese. It appears to have reached Fiji about the middle of the last century, for in 1861 Seemann wrote that "this plant is quite a recent introduction and the natives have not yet taken to its cultivation". (2) It seems that the Fijian people did not take to the crop for some considerable time, for in 1880 John Horne (3) wrote that it was not much relished in Fiji either by the natives or by the Europeans. He recorded seeing single plants and occasionally small plantations in the vicinity of several native towns, and also seeing it growing like a wild plant in many places in the forests.

The crop is now widely grown by the Fijians in all parts of the country. Although it grows both in the wet zone under a rainfall averaging 130 inches per annum and in the dry zone with 70 to 80 inches, it does best in the intermediate zone. Its cultivation in the Pacific is discussed by Massal and Barrau (4). In Fiji this plant is particularly free from pests and diseases. Although a crinkled-leaved variety was for a short time feared to be the result of a virus infection, tests by grafting proved that this was not the case.

A variety collection was begun in 1950, from which 14 separate varieties were obtained. It will be seen from the list that on two occasions different varieties were received under the same name. There are probably a few more varieties in isolated parts of Fiji; these 14 however have been put through variety trials at Koronivia and at Sigatoka. A further two varieties with variegated leaves are also described.

Varieties described below have been grouped according to the colour of the young leaf-bearing part of the stem. This may be yellow green, green, dark green, or brown green. The amount of red pigment in the petioles varies from the faintest trace to complete coloration; but in most varieties the central part of the petiole is coloured red or purple and the ends are green apart from the extreme basal part which, with the persistent parts of the stipules, is red. This gives a banded effect to the petioles. The colour of the mature stem varies from red brown to a silvery grey. Branching of the stem may occur low down near the soil, half way up the stem, or near the top; sometimes it occurs in more than one position, and sometimes it does not occur at all. Roots are pale skinned or brown, and may be long or short, slender or fat. Short fat roots normally have a shoulder near the stem, being similar in shape to a parsnip. Leaf shape is not generally of much use as a character for recognition, apart from a highly distinctive crinkle-leaved variety. Colour also is of little use although in some varieties the young leaves are distinctively dark.

KEY TO IDENTIFICATION OF VARIETIES

A1 Leaf crinkled ... ... COCI
A2 Leaf flat :
  B1 Leaf variegated :
    C1 White outside, green centres . ... YASAWA
    C2 White centres, green outside . ... MACUATA
  B2 Leaf uniform in colour :
    D1 Petioles green (Redness absent or insignificant) :
      E1 Young stem green, robust plant ... ... BELESILIKA
      E2 Young stem yellow green, small plant :
        F1 Much branched stem, many flowers ... ... NOUMEA
        F2 Little branching, no flowers ... ... YABIA VULA
    D2 Petioles uniformly red, or nearly so :
      G1 Young stems green ... ... KATA FAGA
      G2 Young stems dark, purplish-green ... ... YABIA DAMU
    D3 Petioles banded with red :
      H1 Young stems yellow-green :
        J1 Roots brown skinned ... ... AIKAVITU
        J2 Roots pale coloured :
          K1 Leaflets highly pointed, young leaflets dark VULA TOLU
          K2 Leaflets less pointed, young leaflets not dark ... ... VULA TOLU 2
      H2 Young stems dark green :
        L1 Young leaves very dark ... ... SOKOBALE
        L2 Young leaves not dark :
          M1 Old stems red brown ... ... MERELESITA 2
          M2 Old stems brown :
            N1 Young stems round ... ... MANIOKE
            N2 Young stems flat-sided ... ... MERELESITA

VULA TOLU is probably the most popular variety. It is considered to be one of the best in quality, and was the heaviest yielder in recent trials. It is of average height and does not flower. The stems branch low down, on the original cutting, and are pale grey in colour. The petiole is red at the base and is banded with red in the centre, the ends being a yellow green. The bracts at the base of the petioles are the usual dark red. The young leaves are rather dark. The leaflets extend to a very fine point. The roots are long and fat and the skin colour is pale brown. Although the name means " three months ", it is not ready to eat until seven or eight months old.

VULA TOLU No. 2 is a different variety which was collected under the same name. Its yield is greatly inferior to the true Vula Tolu and its roots are thin. Its stem and roots are slightly browner than Vula Tolu, and it does not branch so freely. The stems are a little thicker and the leaves are slightly less pointed than Vula Tolu, which it closely resembles in all other ways.

MERELESITA is another widely grown variety. It is extremely tall, and is dark in colour ; the stems are brown at the base and a dark grey green at the tips. Occasional branching occurs half way up the stems. Young petioles show some purple coloration but older ones are dark green. The roots also are dark in colour.

MERELESITA No. 2 is another case of a different variety having been collected under the same name, but differs more from the true Merelesita than does the second Vula Tolu. It is an average yielder, and is rather tall. The stems are thick, and red brown—a colour shown by only two other of these 16 varieties (Kasaleka and Coci). The leaf stalks are pale red, the young stems being dark green ; the roots are pale brown.

YABIA DAMU is easily recognized by its straight unbranched stems and the bright red petioles from which the name "damu" arises. The old stem is the usual pale grey, the young stem and the leaves being dark. Its height is below average. It is a good yielder and the roots which are brown skinned are considered to be of good quality.

YABIA VULA is distinguished by its almost complete absence of red pigment, the Fijian word "vula" meaning white. The leaf stalks are yellow green in colour. It is a rather tall variety, but does not yield heavily. The leaflets are wider than average.

NOUMEA is another easily-recognized variety; it is short, and the stems are highly branched, exhibiting low, central, and high branching. It also flowers very freely. The leaf stalks are green with little redness, and the roots are brown skinned. Yield is low.

COCI is the most easily distinguished of all the 16 varieties for it has a unique crinkled leaf. It was once feared that this might be a virus, but grafting experiments proved that this is not the case. There has been a peculiar difference in its growth on the two stations, although it has yielded well on both. At Koronivia it has always been one of the shortest varieties while at Sigatoka it became one of the tallest. The stems are reddish and only branch slightly, low down. The leaf stalks are slightly reddened at the ends, and the skin colour of the roots is brown. Together with the crinkling of the leaf margins is shown a definite discoloration or paling of the leaf centres; this becomes less noticeable with age, and the crinkle also appears to be reduced in older leaves.

SOKOBALE (Laione) appears to be a particularly long term variety. It is slightly above average in height. The stems branch to some extent both in the middle and high up, and are rather thick. The young stem is dark green, and the young leaves are very dark in colour. The leaf stalks are the usual banded red, and the skin colour of the roots is the usual pale brown, but in shape these are rather short and fat, with a shoulder near the stem.

AIKAVITU is very similar but does not branch so much, and is a poor yielder. It flowers to a limited extent. The petioles have little red colour on a yellowish-green background. The stems are medium in height and are rather thin. The roots are brown skinned.

KASALEKA (Vakaruru, Ba voisodoi, Drauibi)—The translation of the Fijian name is "short petiole". It is a short variety with a rather strong reddish stem, with the usual slight low branching. The colouring of the base of the leaf stalks is a dark red or purple, the young stem being a brownish-green in colour.

KATAFAGA (Tavioka ni Idia)—This variety was actually obtained from the island of Katafaga under the name "vula tolu". It is similar in height, stem colour and root colour, but the stems branch in the middle and near the top to some extent. The petioles vary from banded to uniform red and lie rather close to the stem instead of standing out from it. This variety produces flowers.

BELESILIKA is medium in height and the stems branch in the middle and at the top. The tip of the stems and the leaf stalks are green with very little red pigment. Leaf size is rather small, and young leaves are rather dark. Flowers are produced. The skin colour of the roots is brown, and they are short and fat but yield is low.

MANIOKE is the poorest yielder of all. It is similar to Belesilika in root and stem colour but is taller and the petioles and stipules are purple. It flowers and branches slightly, less freely than Belesilika. The young stem is dark green and has a distinctive round appearance, and is angled rather than straight.

YASAWA—This and the next variegated variety have not been grown under trial conditions. The variegation of this variety makes it stand out clearly. The outer parts of the leaflets near the tips are a silvery white, the leaf centres being a pale grey green. The stem is grey at the base and green at the tip, and does not branch to any extent. The petioles are a pale red and the stipules a rather darker red. The roots are long and slender.

MACUATA—This is variegated in the opposite manner to Yasawa, the outside of the leaflets being a normal green

and the inner areas being a yellow white. The young stem tip is yellow-green and the petioles are dark red right through. The stem is very highly branched, and it produces large numbers of flowers. The plant is very small and delicate and its bright colours and flowers make it attractive as an ornamental plant. It does produce roots, however ; these are short and thick with a distinct shoulder.

Trials of these varieties have been carried out both on the Principal Agricultural Station at Koronivia in the wet zone, and at the Agricultural Station, Sigatoka, in the intermediate zone. A randomized block layout was used and plots were split to provide two times of lifting, in order to obtain information on rate of maturity. In two of the trials, plots were split again for application of a nitrogenous top dressing. Heights were recorded and dry matter contents estimated from each plot ; the hydrocyanic acid content was analysed by the Biochemist.

Mean yields from these trials are given in Table I. It will be noticed that the highest yields were obtained under the drier conditions at Sigatoka, and at Koronivia in the dry year 1953. Yields ranged from under 3 tons to 14 tons, and the relative performance of the varieties was very consistent. The variety Vula Tolu was the highest yielder on three occasions and the third highest yielder in the fourth trial ; in two trials it significantly outyielded all other varieties. The figures given in Table I are the means of early and late lifting ; the highest yield of all was 16.14 tons per acre given by Vula Tolu lifted at 12 months (late lifting) at Sigatoka. This variety is popular with the Fijians who like its eating qualities, for it is neither woody nor too soft, even when dug very young. Other varieties considered to be of good quality are Yabia Damu, Coci, and Merelesita ; all three are also heavy yielders and fairly quick maturing varieties. At the other end of the scale are varieties such as the consistently poor yielder manioke, which is very woody. It seems that this was an early introduction which is not now grown but which propagates itself in the bush ; in Beqa, for example, it occurs quite frequently beside the tracks but is not seen in cultivation.

The growing period of the early lifted plots varied between different trials from 8 to 10 months, but all the late lifted plots had 12 months in the ground. Extra growth in the period between early and late lifting varied greatly between the trials and appears to be affected both by the variation in time interval and by the climatic conditions. In only one year were the differences significant between the varieties with regard to their rate of increase between the two dates of lifting. However the figures in Table I show that while Coci and Vula Tolu made very little extra growth in this period—that is, that they were nearly mature at the earlier date—other varieties such as Manioke and Sokobale were still growing very actively. Sokobale is the obvious choice for a variety to be left in the ground for a long period.

In two of the trials (1954 and 1955 at Koronivia) the plots were split for a top dressing of sulphate of ammonia at the rate of $1\frac{1}{2}$ and 2 cwt. per acre respectively. (This was given in three or four applications of $\frac{1}{2}$ cwt. each). In neither case was the interaction between varieties and nitrogen significant—that is, all the varieties responded in much the same way. The mean effect of the nitrogen was to give increases of 10.0 per cent and 10.8 per cent in 1954 and 1955 respectively ; both of these were highly significant. In each case the increase was slightly greater with the earlier lifted plots than with the later lifting, but the interaction did not attain significance.

The percentage of dry matter in the roots did not vary significantly between varieties, although Kasaleka and Merelesita were low in the early lifted plots both at Koronivia and Sigatoka. Kasaleka was still low in dry matter in the later lifted plots but Merelesita had increased greatly.

The late lifted crop showed a greatly increased dry matter content, as the roots were more mature. The mean increase amounted to 8.9 per cent at Koronivia and 21.0 per cent at Sigatoka. The application of nitrogenous fertilizer had no effect on the dry matter content.

TABLE I

YIELDS OF ROOTS IN TONS PER ACRE FOR FOUR TRIALS, AND PERCENTAGE INCREASE WITH LATE LIFTING

	Yield in tons per acre					Percentage increase with late lifting				
Variety	Mean 2-3 trial P.A.S.	1953 Mean P.A.S.	1954 Mean P.A.S.	1955 Mean P.A.S.	1955 Mean A.S.S.	P.A.S. '53	P.A.S. '54	P.A.S. '55	A.S.S. '55	(Mean of Order 4 trials)
Vula Tolu ..	8.24	10.60	6.24	7.89	14.00	2.8	34.3	— 3.2	36.1	2
Merelesita ..	7.16	9.28	5.78	6.41	9.50	12.1	46.5	11.6	57.8	7
Coci	6.83	8.34	7.26	4.88	10.45	14.6	13.3	1.9	25.5	1
Aikavitu ..	6.81	9.57	5.87	4.99	9.93	6.4	61.1	— 2.6	32.7	3
Yabia Damu ..	6.65	7.85	6.16	5.95	9.71	17.4	26.2	14.7	57.6	6
Merelesita 2 ..	6.22	..	7.03	5.41	11.20	..	44.7	21.2	32.5	8
Sokobale ..	5.98	7.63	5.02	5.28	8.63	32.7	88.8	53.5	102.0	14
Kasaleka ..	5.93	8.38	3.96	5.44	9.48	22.3	41.4	45.7	59.9	12
Vula Tolu 2 ..	5.27	6.59	4.23	4.99	7.54	17.7	42.0	2.6	36.7	4
Noumea ..	5.15	7.50	3.88	4.07	6.57	15.6	80.5	16.7	43.4	10
Belesilika ..	4.79	..	5.48	4.10	6.68	..	17.6	—24.9	62.7	9
Yabia Vula ..	4.75	..	4.90	4.51	6.92	..	28.6	12.7	79.5	11
Katafaga ..	4.73	..	5.78	3.67	9.25	..	54.8	—13.2	43.9	5
Manioke ..	3.42	4.61	2.97	2.68	5.43	48.2	75.0	31.2	103.8	13
Mean	..	8.04	5.33	5.02	8.95	15.59	42.30	10.2	49.96	
Sig. Diff: 5%	..	1.88	1.05	1.06	2.43	N/S	N/S	Int. Sig.	N/S	
1%	..	2.70	1.39	1.42	3.30			at 0.1%		
0.1%	..	3.97	1.79	1.87	4.41					
Months ..	..	..	..	..	..	10 or 12	8 or 12	8 or 12	9 or 12	

TABLE II

DRY MATTER PERCENTAGES

	Koronivia		Sigatoka		
Variety	8 months	12 months	9 months	12 months	Mean
Coci	36.8	41.6	37.6	46.9	40.7
Belesilika ..	37.3	40.4	40.4	44.6	40.7
Manioke ..	36.4	40.9	38.5	45.9	40.4
Vula Tolu 2 ..	37.5	41.0	38.5	44.2	40.3
Yabia Damu ..	36.9	37.8	39.1	45.3	39.8
Merelesita 2 ..	36.1	41.0	36.0	45.9	39.8
Katafaga ..	36.3	36.5	42.3	43.8	39.7
Sokobale ..	37.2	40.7	37.7	41.5	39.3
Yabia Vula ..	36.3	39.5	35.9	44.7	39.1
Merelesita ..	32.9	42.8	33.9	44.9	38.6
Aikavitu ..	36.1	36.8	38.6	42.8	38.6
Vula Tolu ..	37.0	39.6	36.1	41.1	38.5
Noumea ..	37.3	35.6	36.7	42.0	37.9
Kasaleka ..	31.6	36.1	30.2	42.1	35.0
Mean	36.12	39.31	36.35	43.99	38.94
Increase ..	8.9%		21.0%		

The records of height in the two trials at Koronivia and Sigatoka in 1955 are very consistent apart from the two varieties Manioke (which was tall at Koronivia and short at Sigatoka) and Coci (which was the opposite). Possibly this is due to their difference in response to the more fertile Sigatoka soils. The heights recorded in Table III are the means of four and three plots respectively. Although certain varieties show a greater increase in height following the application of fertilizer than do other varieties, there is no correlation between this increase and the increase in weight of roots; nor is there any connexion between the heights of different varieties and their yield of roots.

TABLE III

HEIGHT OF CASSAVA IN FEET

Variety	P.A.S. Lifted at 8 months Unmanured		P.A.S. Lifted at 8 months Manured		P.A.S. Lifted at 12 months Unmanured		P.A.S. Lifted at 12 months Manured		P.A.S. Mean		A.S.S. Lifted at 8 months		A.S.S. Mean		A.S.S. Lifted at 12 months	
	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Merelesita	6	5	8	8	8	2	8	8	7	11	9	4	12	0	10	8
Manioke	5	11	7	6	7	11	8	5	7	5	9	0	9	2	9	1
Yabia Vula	5	5	7	6	6	11	8	0	6	11	9	0	11	3	10	2
Sokobale	5	10	6	9	6	9	8	0	6	8	9	4	10	0	9	8
Aikavitu	5	3	6	8	6	10	7	10	6	8	9	4	9	8	9	6
Katafaga	5	7	6	1	7	2	7	8	6	7	9	1	9	6	9	4
Merelesita 2	5	8	6	11	5	8	7	9	6	6	9	8	11	4	10	6
Vula Tolu 2	5	5	6	8	6	8	7	4	6	6	8	2	9	9	9	0
Vula Tolu	5	1	6	3	6	1	7	1	6	2	7	8	9	4	8	6
Belesilika	5	6	6	0	6	7	7	7	6	6	8	4	9	4	8	10
Noumea	5	8	5	6	6	9	6	1	6	0	8	4	8	1	8	3
Yabia Damu	5	6	4	10	6	4	6	9	5	10	7	8	9	0	8	4
Coc.	4	9	5	4	5	9	6	6	5	7	9	6	11	4	10	5
Kasaleka	4	8	5	10	4	9	6	2	5	4	6	4	7	7	7	0

TABLE IV

PERCENTAGE OF HYDROCYANIC ACID

Variety	HCN Content — of peel	HCN Content — of flesh
Katafaga	0.064	0.009
Kasalakea	0.069	0.008
Aikavitu	0.047	0.006
Manioke	0.035	0.006
Belesilika	0.054	0.004
Yabia Damu	0.052	0.004
Yabia Vula	0.059	0.003
Sokobale	0.053	0.003
Vula Tolu	0.049	0.003
Coci	0.047	0.003
Merelesita 2	0.028	0.003
Merelesita	0.027	0.003
Vula Tolu 2	0.038	0.002
Noumea	0.025	0.002

The figures in Table IV show the hydrocyanic acid content of roots harvested at eight months in the 1954 trial at Koronivia. Katafaga and Kasaleka are the varieties with the highest HCN content. None of these varieties show the high HCN content of the flesh said to be typical of bitter cassava (*Manihot esculenta* Grantz); yet all of these varieties which flower produce winged seed capsules. This is said by Massal and Barrau (4) to be a recognition characteristic of *M. esculenta*, the sweet cassava *M. dulcis* (Pax.) having no wings on the capsules, and having in general green coloured and not reddish stems.

To conclude, it has been found that the variety Vula Tolu is usually the highest yielder under both wet and intermediate zone conditions. This is a popular variety which can be eaten earlier than most others, or left in the ground for a year at least. The dry matter content of its roots is probably not as high as some other varieties, but the difference appears to be slight. It is a popular variety and widespread use of it is justified. The variety Coci appears to do particularly well on the alluvial soils of the Sigatoka. Both these varieties are early-maturing; Sokobale would be useful for a crop which is to be left in the ground for a long time. The range in hydrocyanic acid content of the flesh is from 0.002 per cent to 0.009 per cent but none of the popular varieties has more than 0.004 per cent.

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NAVUA SEDGE

An aggressive weed which is capable of smothering most of the pasture grasses of the Colony. It should be treated as a noxious weed and every effort should be directed towards preventing its further spread.

Kyllingia monocephala Rottb. *Family: Cyperaceae.*

Figure 16. NAVUA SEDGE (*Kyllingia monocephala*). (a) habit x ½: (b) spikelet x 15

Figure 1—

The stem of Navua sedge is triangular in shape, solid or pithy, and is not enclosed by a leaf sheath. The tapering pointed leaves are clustered round the base of the stem and are in three ranks with very short sheaths. The erect stem has six leaf-like bracts given off from its apex. Four of these bracts are long and two are short. On the apex itself is a button-shaped cluster of flowers or spikelets.

Botanical description—Perennial, herbaceous. Culms erect, 3-angled, 1 to 2 feet (30 to 60 cm.) or more high. Leaves 3-ranked, clustered at base, drooping, 2 to 6 inches (5 to 15 cm.) long and $\frac{1}{8}$ to 3/16th inch (3 to 4.5 mm.) wide ; leaf sheaths short, complete ; ligule absent. Spikes terminal, ovoid to cone-shaped, silky, white; spikelets approximately $\frac{1}{8}$ inch (3 mm.) long ; subtending leaf-like bracts 6 usually ; 2 short bracts, 1 to $2\frac{1}{2}$ inches (2.5 to 6.2 cm.) long, 1/16 inch (1.5 mm.) wide ; 4 long bracts, 3 to 5 inches (7.5 to 15 cm.) long, $\frac{1}{8}$ inch (3 mm.) wide, tapering to a point. Fruit a nut, brown, becoming blackish.

Distribution—A tropical species recorded from India and other warm regions of the Old World which has undoubtedly been accidentally introduced to Fiji. As the common name implies the sedge first became prominent at Navua where it is a serious pest of pastoral lands. It now covers large areas in the Colony and is spreading rapidly. This weed has probably been spread by cattle and also in mud on lorries or cars travelling from infested areas.

Specimens of any plants suspected of being Navua sedge should be sent to the Botany Laboratory for identification. Specimens should have roots, stems, leaves and flowers and should be pressed between two sheets of newspaper or blotting paper if they are likely to take more than a day to reach Suva. *Great care should be taken to ensure that the seeds are not spread. Specimens when collected should be placed straight into an envelope or other suitable container.*

—J.W.P.

COPRA . . .

THE SAMPLING OF COPRA IN FIJI IN RELATION TO ITS MOISTURE CONTENT

BY N. G. CASSIDY

SCOPE

Since moisture content is the factor most directly affecting mould growth in copra, and since it is the factor most subject to control by the producer, its prime importance to the industry is obvious.

It was required to know the variability in moisture content of copra being received at Suva, which is the major grading and shipping centre for Fiji, in order that a rational basis could be established for sampling.

METHODS

Moisture was determined by Toplis-Simpson Electric Meters. A preliminary investigation had shown that with due precautions these meters could be relied on to give sound comparative readings. For accurate *absolute* values of moisture content, a calibration curve constructed from copra samples of known moisture content is required for each meter. The precautions to be taken in the correct use of these meters are :—

(1) Sufficient " warming-up " time must be allowed at the beginning ; 20 minutes is required for certainty.

(2) The material must be properly prepared ; a suitable grater produces pieces about half an inch long by one eighth of an inch thick, and the size used for calibration purposes must be used for all subsequent measurements.

(3) Sufficient time must be allowed after adding the grated material to the electrode cup ; 2 minutes is required for a steady reading.

(4) The electrode cup should be filled from a small metal chute without the application of any pressure.

(5) The batteries must be kept well charged or drifting effects will be experienced.

EXPERIMENTAL

On two occasions chosen at random, namely in March, 1950, and again in May, 1950, the copra being received at King's Wharf, Suva, was sampled by consignments. Seven consignments were selected at random except that small lots of less than 40 sacks were ignored. From each consignment five individual sacks were taken at random. A sub-sample was taken from each of the individual sacks in the following way. The sack was emptied on to the floor and the contents well mixed with a shovel. The heap was then quartered and a handful of copra taken " blindfold " from each quarter. (The handful was made sufficiently large to include the big as well as the small pieces present). The four handfuls were then mixed, halved to reduce bulk, and passed through the grinding machines. The resulting material, representing one sack of the consignment, was then ready for measurement.

A domestic vegetable grinder with punched cone grinding surfaces was used in preparing samples of the first series, but in the second series, owing to mechanical weakness this was replaced by a meat mincing machine. The latter was much more robust and proved satisfactory provided the small quantity of oil which it expressed in the grinding process was incorporated again with the rest of the sample. This difference in method of preparation does not affect the estimation of moisture variation either within or between consignments. It only means that a different factor for each series would be required to transform meter readings to percentage moisture.

As a precautionary measure two moisture meters were used and each sample was read first in the one meter and then in the other. The Appendix shows the detailed findings and these are referred to later, under the heading Results.

EFFECT OF STORAGE

An important factor affecting the moisture in copra is the gradual change which takes place during storage. Interesting results were obtained during a trial to find how long copra of a given moisture content would keep in sealed containers when preserved with chloroform. A very dry and a moist sample were each placed in storage (in the grated condition) on 12th December and frequent moisture readings were made on the meter for more than a month. After a time it was realized that the short period of exposure during the taking of readings was sufficient to alter the moisture content of either very dry or very moist copra. It was found that at the prevailing relative humidity of Suva (70 per cent-80 per cent) these grated samples changed their moisture content rather quickly and tended to assume an equilibrium value of about 7 per cent moisture.* The loss of weight which takes place in ordinary copra stored in warehouses is, of course, a well known fact and due allowance is always made for it. With copra of high moisture content the drying of the outside layers no doubt contributes largely to the variations in moisture which are found in any commercial consignment.

A graph showing the tendency to equilibrium by the preservatized samples mentioned above, is shown on page 96. The over-drying effect which occurred with the moist sample during the first week of the trial is perhaps explained by the low value for relative humidity (61 per cent) which was registered at this time.

RESULTS

The last column of the table in the Appendix gives the number of sacks which must be taken from each consignment, using the sub-sampling technique described above, in order to obtain an estimate which is correct to within plus or minus 10 per cent of its true value at the 5 per cent level of significance ; that is to say, in 95 times out of 100. To state an actual example, this means that for a copra with 7 per cent moisture the error should not be greater than 0.7 per cent of moisture in 95 cases out of 100.

It will be seen from the table that the number of sacks which must be sampled from each consignment in order to fulfil these conditions, ranges from three to eight, depending on the coefficient of variation of the consignment. In order that consignments of great variability may be covered, it is necessary to take eight as the number of sacks for all cases.

SUMMARY

The variability of moisture in Fiji copra has been investigated.

Moisture was determined by Toplis-Simpson Electric Meters ; precautions to be observed in the use of these meters have been listed.

In order to obtain an accuracy of plus or minus 10 per cent of the true value of moisture content, eight sacks must be sampled from each consignment.

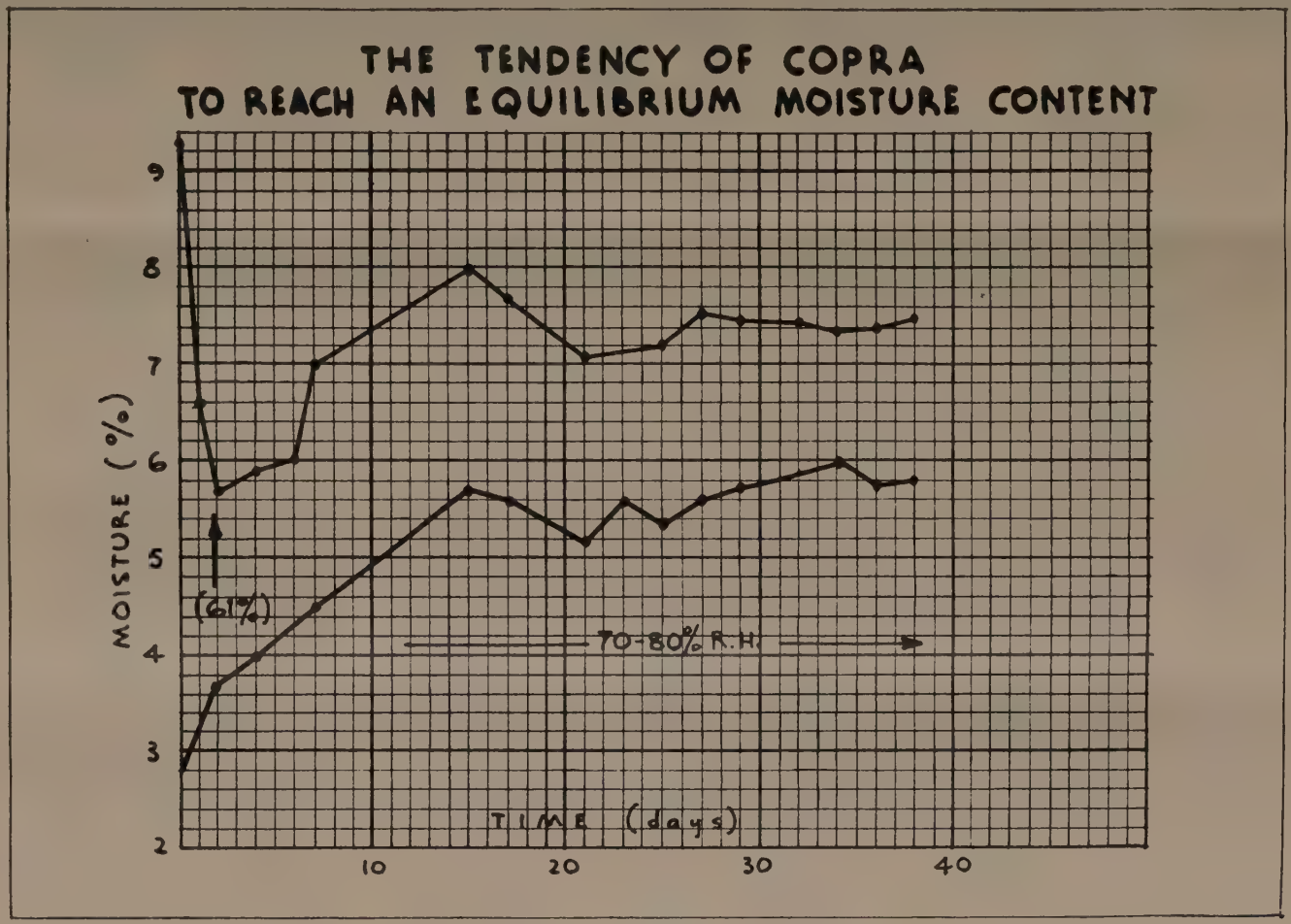
The tendency of very wet or very dry copra to come to the same equilibrium moisture content when exposed to the atmosphere, has been noted and its relationship to moisture variability in commercial consignments has been pointed out.

APPENDIX

THE VARIABILITY OF COPRA CONSIGNMENTS WITH REGARD TO MOISTURE CONTENT

Series	Meter	Coefficient of Variation in moisture content	Calculated No. of bags to be sampled
I	No. 3	6.8%	6
	No. 4	8.6%	8
II	No. 3	4.8%	4
	No. 4	3.1%	3

* It should be realized that in this experimental work involving replicate readings on more than one meter the total exposure was much greater than in making a single routine reading.



The approach to a moisture equilibrium by ground samples of copra which were exposed to the atmosphere.

COPRA DRYING EXPERIMENTS

I. RELATIONSHIP BETWEEN RATE OF DRYING AND RELATIVE HUMIDITY

BY V. E. SILLS

SUMMARY

There is still a good deal to learn about the physical behaviour of copra during the process of drying in hot air. The experiments described below show clearly how the artificial moistening of air inside a hot air drier can speed up the rate of drying of copra.

CASE HARDENING

The control of the moisture content of air used in the process of drying fresh fruits in commercial dehydrators has been practised as long as the fruit dehydration industry has existed. When most kinds of fruit are artificially dried at temperatures over 150° to 160° F. a skin forms on the outer surface of the fruit at a certain stage of the drying which hinders the natural movement of water from the central parts of the fruit flesh towards the surface. This phenomenon is known as " case hardening " and is caused by water evaporating from the fruit surface at a greater rate than it can be supplied by the process of diffusion. The surface of the fruit becomes dry and a skin is formed which bars the passage of water. At high temperatures, of the order of 180°F. and with dry air, this skin can bring the process of dehydration to a halt, even though a considerable amount of moisture has still to be removed.

There are two methods of preventing case hardening. First, the temperature can be lowered gradually as drying proceeds. Second, the relative humidity of the air during the later stages of drying can be raised artificially : either steam can be admitted, or a proportion of the air which has already passed over the fruit can be recirculated.

Whether these principles apply to coconut kernel in the same way that they do to fruit is doubtful. The two materials are very different in composition ; one is high in water and sugar content, the other contains comparatively little water and sugar but possesses a large amount of oil. It has been proved, however, that pieces of coconut kernel do dry faster in artificially moistened air than in dry air for a given temperature above 160°F. The difference in the rate of drying is not great but it is enough to be of practical importance when seeking a method for drying copra quickly. Rapid drying of copra at temperatures above 160°F. does not produce copra of such good appearance as one dried at cooler temperatures over a longer period. Perfectly white copra can be prepared if careful drying is extended for a period of 36-48 hours, but whether it pays to aim at this high standard is a question which only the producer himself can answer. It certainly will not pay him to attempt the drying of copra in so short a time that scorching can take place. A compromise is perhaps the best solution.

EXPERIMENTAL

The rate of drying of coconut kernel in air at various temperatures and of different relative humidities has been tested in the laboratory with the aid of an improvised hot air drier constructed out of a large biscuit tin and fitted with an electric hot plate, a constant level waterbath, thermostat and wire tray. The tray was so arranged that it could be lifted out of the drier, weighed and returned to its original place in the space of less than a minute. Thermometers could be inserted at any point within the drier for the purpose of reading off temperatures and determining relative humidities. The flow of air through the apparatus could be controlled by opening or closing the holes in the bottom of the tin and by regulating the size of the opening in the top of the tin.

Freshly cut coconut kernel in pieces of about one ounce in weight was placed on the tray at the rate of 2½ lb per square foot. The rate of drying was determined by weighing the tray and contents at regular intervals over a period of 24 hours.

RESULTS

The graph (Fig. 1) illustrates how the copra behaved when dried at 170°F., in one case with artificially humidified air, and in the second, with normal dry air. For the first four hours of drying the surface moisture of the coconut kernel kept the air moist inside the drier ; the addition of extra moisture from the waterbath served no useful purpose. During the ten hours that followed, however, the two rates of drying diverged, as is depicted by the curves on the graph, showing that the air with the higher relative humidity did in some way cause a more rapid loss of moisture from the copra. When the drying had continued for 14-15 hours the rate of drying slackened off until it reached a low but fairly constant value. At this stage the drying rate was apparently not affected by changes in relative humidity. The graph clearly shows that after a total drying time of 24 hours the sample dried over the waterbath contained the lower percentage of moisture. Another way of expressing the difference is to say that it took about six hours longer to obtain a shrinkage of 40 per cent without the use of water than it did with it : 40 per cent shrinkage represents about 12 per cent residual moisture.

EFFECT OF INCREASING THE TRAY LOAD

If the rate of loading of the tray with freshly cut coconut kernel is increased from 2½ lb to say 12 lb per square foot (6 inches deep) the effect of raising the humidity is much less marked. The upward flow of air through the tray is impeded by the dense layer of pieces and consequently the drying is slowed down, although of course the conditions improve as the copra shrinks. To obtain an even rate of drying throughout the thick layer it is necessary to turn the copra at regular intervals, otherwise the pieces at the bottom become dry long before those at the top and the total drying time is much prolonged ; in addition, unevenness in quality is bound to occur. Further experiments will be undertaken in the future to determine precisely how the rate of drying varies with different tray loads and drying temperatures.

OPTIMUM HUMIDITY

In the fruit dehydration industry it has been found that a relative humidity of between 30 and 35 per cent at 150°F. is needed to prevent case hardening of certain kinds of fresh fruits (1). In the experiments with copra, described above, the relative humidity of the artificially moistened air, as measured at a point just below the tray, was found to be about 35 per cent during the first twelve hours of drying ; it dropped to 20 per cent in the final stage. Without artificial moistening the figures were 15 per cent lower in each case.

DISCUSSION

The drying of copra in hot air is an operation which can be done well or badly according to the amount of care that is taken with the control of temperature and humidity. Experiments in the laboratory have shown that very hot dry air can do considerable harm to copra by causing it to case harden on the surface so that further drying is made slow and incomplete. Copra prepared in this way is poor in colour and possesses poor keeping qualities ; due to the high residual moisture content mould growth and insect attack soon take place.

Hot moist air on the other hand is much less harmful to copra, and provided that the final stages of drying are conducted at moderate temperatures, a good product, white and well dried, can be made. Because of the time-saving that results from the use of moistened hot air it may be an advantage, in certain instances, to make practical use of the idea in natural draught types of hot air copra driers commonly used on plantations. The investigations on the practical value of controlled humidity will be continued.

REFERENCE

(1) " Commercial Fruit and Vegetable Products ", by Cruess. 3rd Edition, p. 522.

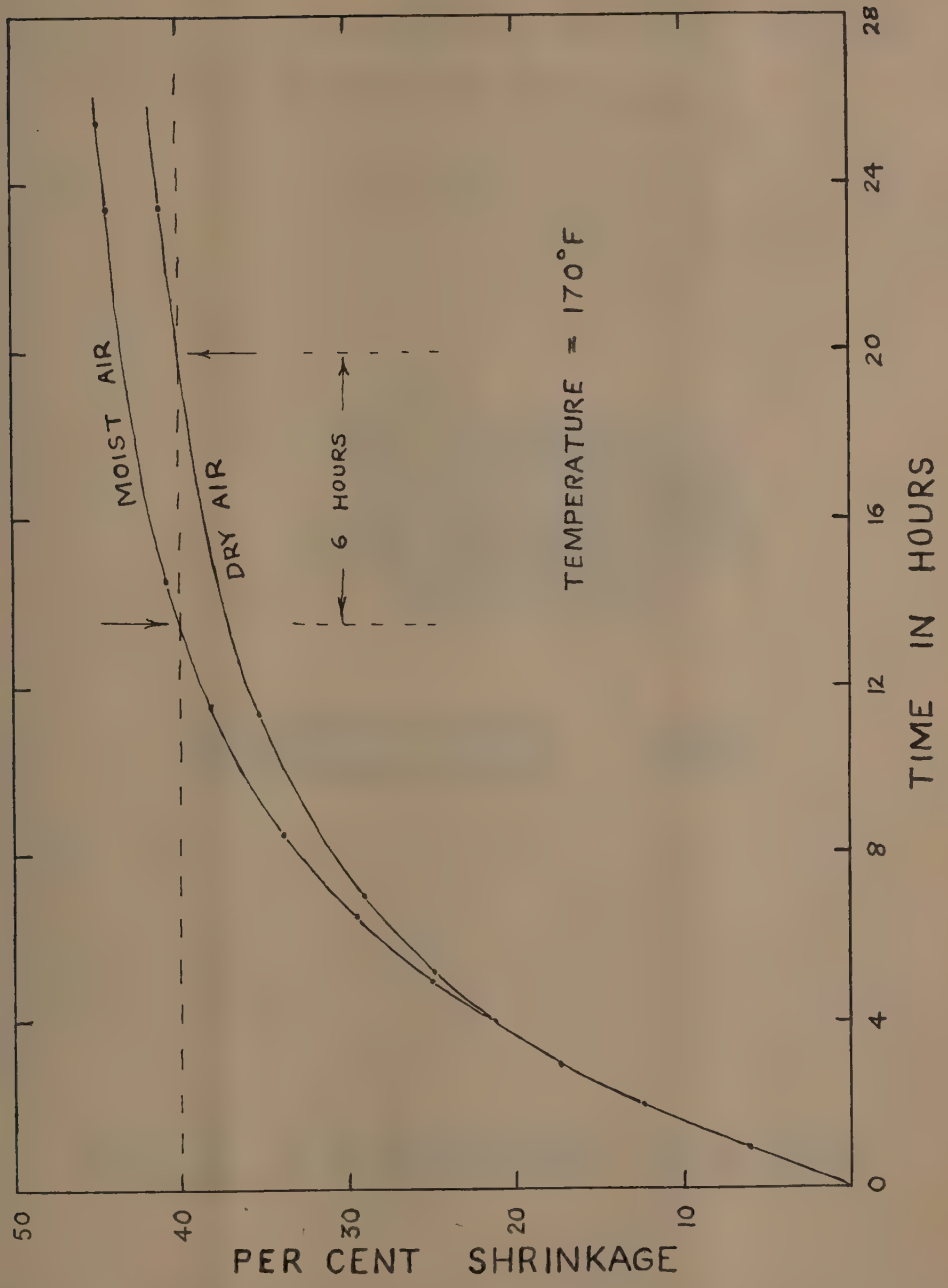


Figure 1—Graph illustrating rates of drying of copra at 170° F.

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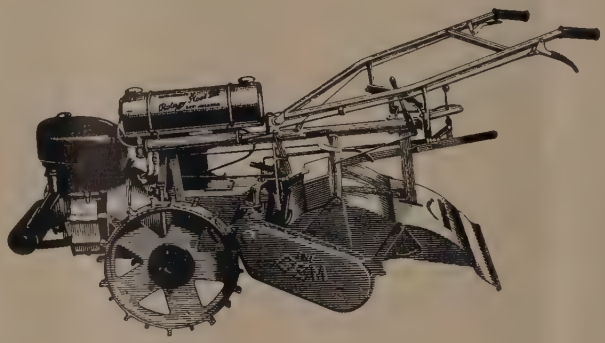

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WEED CONTROL . . .

GUAVA AND ITS CONTROL IN FIJI

BY T. L. MUNE AND J. W. PARHAM

Guava is a declared noxious weed in the Colony of Fiji.

It is a small tree with a copper coloured bark which peels off in thin strips. The leaves are about six inches long and the main veins are very prominent. The flowers are white or cream coloured and have five petals and many stamens. The fruit is globose, green and hard when young but turning to a golden yellow colour and becoming soft when mature. The fruit is very popular especially for the making of jellies and jams.

BOTANICAL DESCRIPTION

Psidium guajava Linn. (*Psidium pyriferum* (Linn.) *Family* : *Myrtaceae.*

Common Names : **Guava : Amrut (H).**

Figure 1. *Plates I to IV inclusive.*

A small tree 10 to 20 feet (3 to 7 m.) high ; trunk slender, branching fairly close to the ground ; bark scaly, peeling off in thin flakes, greenish brown to copper coloured. Leaves on fairly short petioles, oval or oblong, 3 to 6 inches (7.5 to 15 cm.) long and 1½ to 2½ inches (3.7 to 6.2 cm.) wide, glabrous above, pubescent below, main veins prominent. Flowers produced on youngest branchlets, solitary or on several flowered peduncles, axillary ; peduncle ¾ to 1 inch (1.8 to 2.5 cm.) long, bearing two small bracts at apex ; calyx oblong-ovate ; petals five, broadly oval, approximately ¾ inch (1.8 cm.) long, thin, delicate, white or cream coloured ; stamens erect to spreading, numerous, filaments about ½ inch (12 mm.) long ; style about ⅜ inch (9 mm.) long. Fruit globose or ovoid, 2 to 4 inches (5 to 10 cm.) long, yellow when mature, flesh yellow to deep pink ; seeds numerous.

Distribution—The guava originally grew in America and it was found there by the Spaniards who introduced it to many different countries so that it now occurs throughout the tropics. Swanston, in his diary records that he introduced one Chilean guava plant from Dr. Mueller of the Melbourne Botanical Gardens in January, 1863. The guava was planted on Nanu-i-cake island, off the Ra coast. *Psidium guajava* is now naturalized throughout the Colony.

SIGNIFICANCE

A recognized weed throughout the Colony, it has spread with alarming speed laying waste many thousands of acres of pastoral and plantation lands. Its dense growth and prolific fruiting make it an excellent refuge and breeding place for wild pigs and bush cattle and a potential breeding ground for insect pests and plant diseases.

CONTROL

For many years guava has been allowed to establish itself with little or no opposition and we cannot now hope to control it without persistent effort and hard work. It is possible that its total eradication may never be achieved.

It spreads by seed, and there is no doubt that it never would have spread so rapidly or extensively without the assistance of birds and animals, including man, all of whom readily eat its pleasant flavoured fruit. This adds to the difficulty of preventing spread by seed, but if farmers, stockman and landowners would realize that cattle and horses are the major agents in the spread of seed and prevent their movement from guava infested areas during the fruiting season, much would be achieved.

Where infestations occur on arable land, the trees should be up-rooted and the land ploughed several times at short intervals and then kept under cultivation for a number of years.

Plate 1—Guava (Psidium guajava). (a) fruit x $\frac{3}{4}$; (b) leaves x $\frac{3}{4}$; (c) flower x 2.

Where it is desired to use this land for sown pastures, it should be cultivated several times before sowing with grass and kept under observation for a number of years.

In non-agricultural and pastoral districts, where the guava is small or stunted and cultivation not possible, systematic burning is a satisfactory and economic method of control. All stock should first be removed from the area, and the guava should be burned early in August, the grass being allowed to grow until December. The guava will have been killed or seriously damaged by the fire and the new grasses should be encouraged to form a dense cover on the burnt ground, to smother any germinating guava seeds or regrowth from roots and low stumps. In the following July or August the area should be burnt a second time and the grasses allowed to become established before being grazed.

Burning is only recommended for the control of small or stunted guava and has not been found satisfactory for the control of large trees.

Systematic burning should only be used where controlled grazing can be practised, i.e. where paddocks have been fenced or natural boundaries such as gullies or escarpments divide the grazing area.

In the wet zones where it is not possible to burn, young trees up to two feet high may be controlled by grubbing. This is only satisfactory if the plants are cut off two or three inches below the ground level and the sod stamped back to cover the cut roots. This is important, for it appears that only the exposed roots send up new shoots.

CHEMICAL CONTROL

A number of herbicides have been used, with varying success. The most satisfactory has been 2,4,5-trichlorophenoxyacetic acid.

Young plants ten or twelve inches high are killed when sprayed with ester formulations of this herbicide containing 3.6 pounds of acid equivalent per gallon diluted in water at the rate of one in one hundred and sixty. The spray is applied as a fine mist, thoroughly wetting the leaves and stems.

This method of application has not been found satisfactory for the control of larger trees ; it causes rapid defoliation but the treated trees recover.

Ester formulations of 2,4,5-T containing 3.6 pounds of acid equivalent per gallon, diluted in diesel fuel oil (instead of water) at the rate of one in thirty, will kill guava at all stages of growth. The herbicide may be applied to small plants as a fine spray, thoroughly wetting all stems and exposed roots, but basal application to the stem has been found more satisfactory for the treatment of infestations of large trees. The herbicide may be applied as a fine spray or may be painted on with a brush to the base of the stem from two feet above the ground to ground level. All of the bark completely around the stem must be thoroughly wetted with the herbicide and the treatment must be extended to all exposed roots.

The herbicide acts slowly and it is some time before any change is noted. When defoliation is sufficiently advanced to allow the sunlight to reach the bare ground under the trees, useful grasses should be sown and encouraged to form a dense cover. The establishing of a good ground cover is important and is half the battle in the control of germinating guava seeds. In killing the growing trees the herbicide appears to kill the lateral roots only for a short distance from the tree, and from the unharmed section of these roots a prolific sucker growth develops. This presents a special control problem and unless dealt with while the suckers are young will result in disappointment and a waste of time and money. No chemical guava control should be undertaken unless the area can be spot sprayed at three monthly intervals for the first twelve months following the initial treatment, and at regular intervals for the next ten years with 2,4,5-T diluted in water at the rate of one in one hundred and sixty. If these spot sprayings are extended to kill the new weeds invading the area they will assist in the establishing of the grasses.

The seasons do not greatly affect the efficiency of basal treatment and it may be carried out at any time of the year.

Although not affected by the time of application, moisture appears to interfere with the efficiency of the treatment and the herbicides should not be applied when the bark is wet or when rain may fall within three or four hours following application.

—*P. R. O. Photograph*

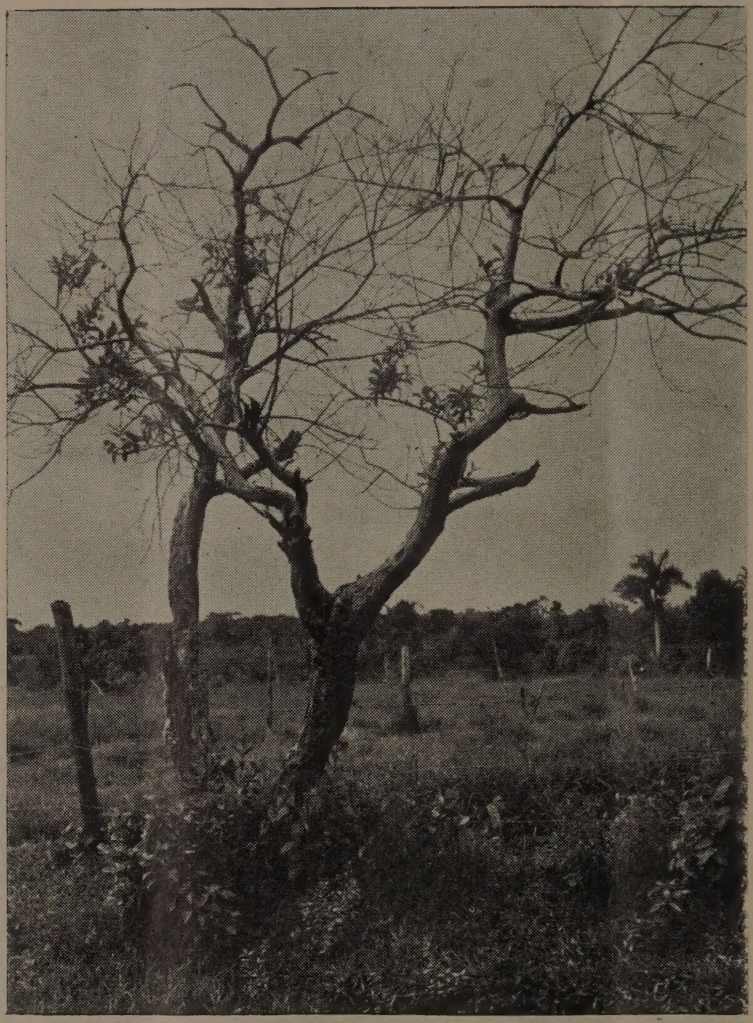
Plate II. Large trees killed with 2,4,5-T in diesel fuel oil

—*P. R. O. Photograph*

Plate III. Close up of large guava trees six months after treatment with 2,4,5-T in diesel fuel oil

—P. R. O. Photograph

Plate IV. Bark peeling from dead trees after treatment with 2,4,5-T and diesel fuel oil



—P. R. O. Photograph

Plate V. A tree which has been insufficiently treated showing vigorous sucker growth and branches which have not been killed

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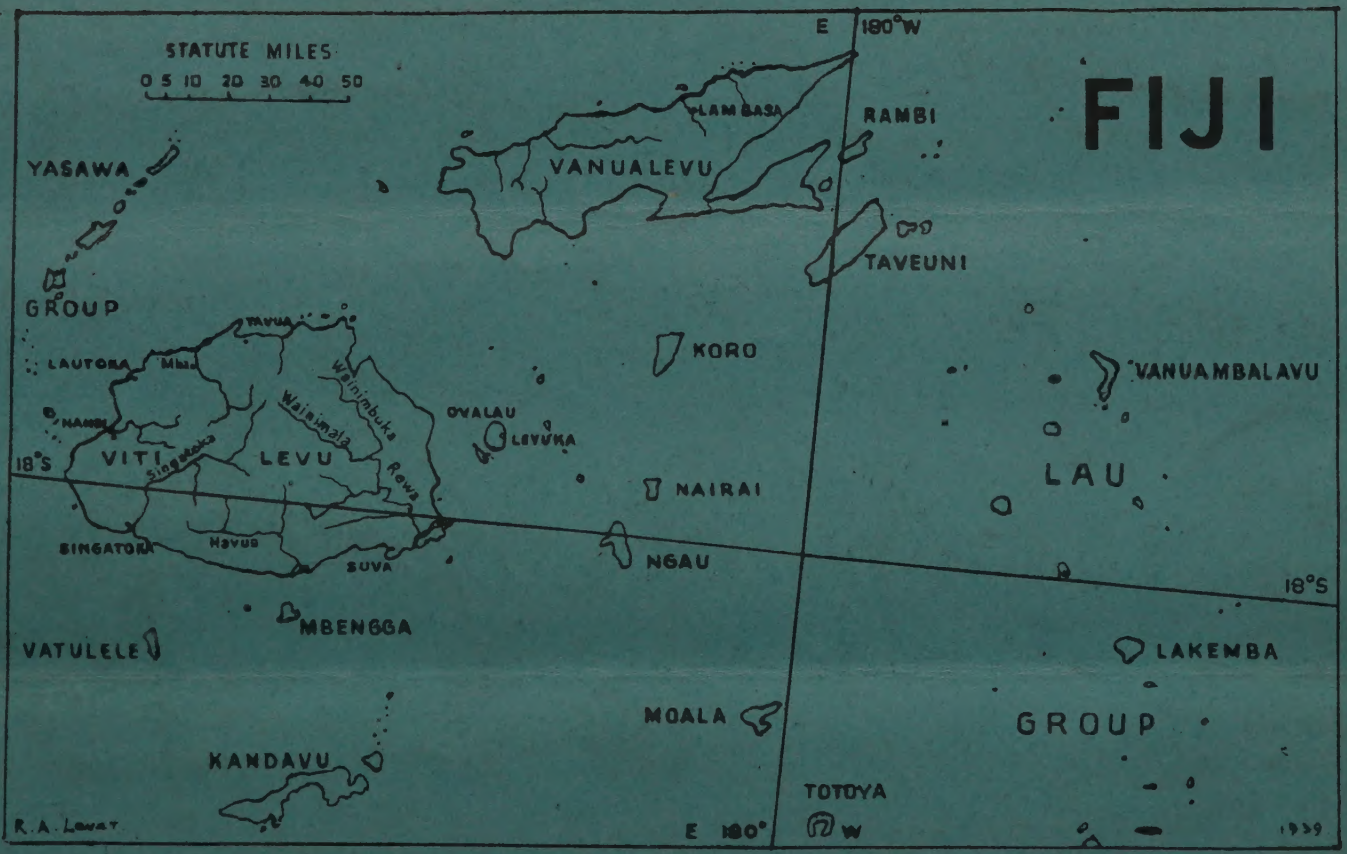

So as to include Kadavu and Totoya within the framework available the map has been rotated some 6° to the east.